RADIOLOGY

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EDITOR

Howard P. Doub, M.D.
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Roentgen Therapy and the Relief of Pain[1]

FREDERICK W. O'BRIEN, M.D.

Boston, Mass.

IN DESCRIBING the properties of x-rays, most authors, when discussing the biological effects, stress the destructive action and make scant mention, if any, of the analgesic effect.

When one reads the suggestion, recently made, that a neurosurgeon do a root resection for post-herpetic pain, one wonders if the radiation therapist has not been remiss in failing to call to the attention of his confreres the very wide usefulness of roentgen therapy as an anodyne in a score of crippling conditions. The importance today of roentgen rays as an analgesic has become so convincing, through the successful relief of pain in such afflictions as boils, carbuncles, bursitis, herpes zoster, Marie-Strümpell's spondylitis, and metastatic bone disease that the radiation therapist is impelled to make the treatment of them current practice. Spaced treatments judiciously applied with a total dosage well within the safety range will, in the majority of patients, bring prompt relief from pain.

BOILS AND CARBUNCLES

The analgesic effect of roentgen irradiation is seen strikingly in such relatively mild lesions as boils, as well as in the severe carbuncle where the inflammatory process has spread to the subcutaneous tissue, causing a diffuse infection with toxic absorption. Of 130 hospitalized patients with severe carbuncles treated by x-rays alone or in conjunction with surgery, as previously reported (1), the 60 who received only roentgen therapy were relieved of pain in three to nine hours after the first treatment. The average number of roentgen treatments was three. The average hospital stay for this group was eight and a half days as against thirteen to twenty-one days for the others. Roentgen therapy is just as efficacious today despite the prevalent vogue for chemotherapeutic agents. At the moment only recalcitrant lesions are referred for roentgen therapy. It is well to know that there is no contraindication to the use of x-rays after the use of the sulfa derivatives or penicillin, the latter requiring hospitalization and both giving rise to undesirable sensitization reactions.

The obvious explanation of the relief of pain following irradiation in boils and carbuncles lies in the relief of the tension in the tissues caused by stretching of the skin secondary to inflammation associated with inflammatory exudate. Pain quickly disappears as the inflammatory process is resolved, with or without the drainage of pus. Some observations have been made which tend to emphasize a close relation between pain and damage to the cells of the skin rather than damage to pain nerve

[1] Presented at the Thirty-fourth Annual Meeting of the Radiological Society of North America, San Francisco, Calif., Dec. 5–10, 1948.

endings. Lewis (2) believes a histamine-like substance is released by damaged skin cells to give an axon reflex. Histamine, however, when pricked into the skin produces itching but not pain. It is now established that cutaneous pain is subserved by fine medullated and non-medullated nerve fibers bearing free endings. These fibers and endings are specific and arranged in a plexiform interlocking manner described as a "sensory unit," in contrast to the single afferent nerve ending. Tower (3) has made it seem likely that a "sensory unit" consists of many nerve endings, all branches of a single fiber connected with a single cell in the dorsal root ganglion. An area of skin about a centimeter in diameter is said to be supplied by such a single unit.

The release of the unidentified pain substance by damaged skin cells, as suggested by Lewis, may be the pain stimulus of the sensory unit. A simple objective explanation is that the tension upon the sensory unit in these lesions is an adequate pain stimulus, for once the tension is relieved the pain ceases.

SO-CALLED BURSITIS

The roentgen treatment of calcification of the supraspinatus tendon, or so-called subacromial bursitis, should always be tried before operative procedures. The relief from pain and the freedom of motion obtained are often dramatic. When one sees a patient with an arm in a sling, sleepless because of pain, appear a day after roentgen therapy and report freedom from pain and a restful night's sleep, it makes one reflect. Such an experience is not uncommon. The diagnosis should, of course, be established by roentgen and clinical examination before irradiation is begun.

No definite etiology has been determined for this condition. Multiple mild traumata appear to prepare the way for the observed roentgen changes. Once these are present, a single severe trauma, such as a fall on the shoulder or with outstretched hand, is sufficient to light up the process. In the acute stages, the pain is intense, often radiating into the neck and down into the arm, with tenderness over the affected area of the shoulder.

The pathology has been described as degeneration of the tendon fibers with round-cell infiltration and occasional giant cells with deposition of calcium salts. Hodges and Phemister (4) agree with Codman that the calcification is always in the tendon rather than the bursal sac.

When analyzed, the calcareous deposit has been found to be about 20 per cent calcium carbonate and 80 per cent calcium phosphate. Occasionally, it has been found as a thick milk-like fluid. When under tension, it has been observed (5) to rupture into the subdeltoid bursa, giving a milky appearance on the roentgenogram.

These calcareous shadows were described by Painter (6) in 1907. He regarded them as having arisen in a thickened bursa. Sandström (7), because he was able to demonstrate dense calcium shadows not only near the shoulder joint but not too infrequently elsewhere as well, producing identical symptoms whatever the localization, believed that these manifestations represented a disease *sui generis*, which he called "peritendinitis calcarea."

There have been few histologic examinations. Sandström and Wahlgren carried out a pathologic-anatomic examination of 13 cases. They found no instance of calcification in a bursa. Microscopically all cases showed necrosis and necrobiotic changes in tendons, ligaments, and joint capsules with surrounding connective tissue. In 10 cases, marked vascular changes were present, in the form of hypertrophy of the media, with narrowing of the lumen and occlusion of several small arteries. There were also signs of regenerative processes in the form of cell proliferation and formation of new vessels. In some cases, there were also giant cells of the foreign-body type. Eight cases showed inflammatory changes, with cell infiltrations around vessels and in the granulation tissue.

The lime deposits, these investigators believe, occur on the basis of pre-existing degenerative changes, as a result of the

prounounced vascular and marked alterative changes. They assume that the disease process consists in local tissue anemia with impairment of vitality. The lime deposits are secondary to these alterations.

In a personal series of 78 consecutive cases of shoulder pain, referred in 1946 and 1947 for radiation therapy, more than 70 per cent showed calcific-like deposits in the region of the supraspinatus tendon. Each patient received four treatments; a few as many as six. The majority reported relief after the second treatment. Only two failed to report complete relief of pain following roentgen therapy.

Treatments were given four days apart, over the affected shoulder joint, 200 r at a sitting, through a 15 × 15-cm. field, with 200 kv., 0.5 mm. Cu and 1.0 mm. Al, at a 50-cm. distance. In cases that fail to respond, it might be well, before employing other methods, to treat the area of the nerve roots of C3, C4, and C5, which supply the skin of the neck and shoulder.

The relief from pain following roentgen therapy in so-called subacromial bursitis may fairly be ascribed to the relief of tension and the resolution of inflammatory products. Freund (8) has shown experimentally that inflammatory cells do not migrate to the site of the inflammation but are formed locally from connective-tissue cells in the blood vessels. In his cases, roentgen irradiation inhibited exudation and decreased the number of inflammatory cells.

We recognize that roentgen therapy is not the only or the necessary means of treating so-called bursitis for the relief of pain. Caldwell, Broderick, and Rose (9), by block of the sympathetic stellate ganglion, obtained immediate relief from pain in 83.3 per cent of their cases. Striking improvement in motion in the joint was noted in all cases. Half of the patients required more than one block, at intervals of from one to seven days. It should be made clear, however, that block of the sympathetic stellate ganglion is a procedure requiring a high degree of precision and surgical acumen.

HERPES ZOSTER

Herpes zoster is another affection in which roentgen therapy has proved valuable for the relief of pain. It is interesting to note that the dermatomes of Head (10) were the result of his concern with this condition. In his time, herpes zoster was thought to result from disease of the posterior root ganglion, which led to the idea that the cutaneous eruption might accurately disclose the distribution of the posterior roots of the skin. Head constructed composite diagrams of almost the whole trunk. The borders of certain of these areas were identified with the borders of sensory loss arising out of cord lesions at known levels. With these and simple anatomical guides, it was possible to number off the remaining areas of his diagrams. Head's areas were contiguous and not overlapping.

Foerster cut the posterior roots in the treatment of pain and found the territories corresponding to adjacent nerve roots to overlap extensively. So great is the overlap, says Lewis, that section of a single root gives little or no sensory change in the skin. One dermatome sometimes overlaps not only the adjacent dermatome but also the one beyond it. This observation is of importance as indicating that the fields for roentgen therapy, directed to the suspected nerve root, should be generous enough to encompass overlapping of the dermatomes.

Several causes can account for herpes zoster. In recent years, it has been thought to be the result of a virus closely related to the virus of chickenpox. Certain it is, that non-specific agents such as cancer, leukemia, arsenic, and trauma (gunshot wounds) can produce all the sensory and skin manifestations of this disease.

Head and Campbell, in 1900, described postmortem findings in 21 cases in which death occurred at all stages of the disease, from three days to over two years after the outbreak of the eruption, and concluded that the primary lesion was an acute round-cell infiltration with areas of hemorrhage in the affected posterior root ganglions, and that changes found in the pos-

terior nerve roots and spinal cord were secondary degenerative processes.

Such views of the pathology of herpes zoster have been challenged by the French school, according to Baird (11), notably by Lhermitte and his collaborators, who in three communications reported acute inflammatory changes not only in the ganglia but also in the posterior roots, the meninges, and the cord itself.

There are two views regarding the skin eruption. One, that the main and primary disturbance is in the ganglion and that reddening, whealing, and blistering of the skin are all secondary phenomena brought about by centrifugal impulses passing out, releasing substances, and setting up an erythralgic state in the skin (Lewis); the second, that the virus spreads along the nerve channels, reaches the skin, and then directly provokes an inflammatory reaction.

Lewis contends, and rightly it appears, that even if herpes zoster proves to result from a virus that spreads along the spinal nerve, such a mechanism would be consistent with the idea that the skin lesions arise out of irritation of this nerve and the centrifugal impulses awakened.

The pain of herpes zoster, then, can be accounted for on the basis of inflammation or degeneration of nerve fibers entering the involved dorsal root ganglion. Pain may precede the appearance of the cutaneous changes and lead to errors of diagnosis. The radiation therapist escapes this pitfall since, commonly, he does not see the patient until the diagnosis has been made.

Keichline (12) in 1934 reported 62 cases of herpes zoster treated by roentgen rays, in 90 per cent of which pain was completely relieved by one treatment. He used low-voltage rays filtered by 3.0 mm. aluminum, at a distance of 30 cm. He gave 148 r only to the "bouquet of herpes zoster" and a similar dosage to the corresponding root ganglion. The field size is not stated.

Of 15 patients with herpes zoster treated by me in 1946 and 1947, 11 were females and 4 males. The youngest in the female group was twenty-nine and the oldest was seventy-three years of age. Twelve of these patients were referred by the same physician from a small urban community, suggesting strongly that this group suffered from a transmissible disease.

In none of my cases was the treatment directed to the eruption. All had irradiation to the region of the spinal nerve roots believed to be involved, through a 15×10-cm. field, the rays being directed slightly obliquely toward the spinal column on the affected side. Not a single case failed to respond to roentgen therapy. There was no report of increased pain following the first treatment, as was the experience of Reeves.

The usual series consisted of four treatments of 200 r each, spaced four days apart. The following factors were used: 200 kv., 0.5 mm. Cu and 1.0 mm. Al, 50 cm., 15 × 10-cm. field. One of our patients, a female aged 55, had twelve treatments, the first 1,200 r within fourteen days and the remainder over a two months period, before obtaining complete relief from pain.

McCombs, Tuggle, and Guion (13) in 1940 reported their results in 72 cases treated by roentgen therapy. Of those treated within seven days of onset of symptoms, 89 per cent were cured. High-voltage radiation was employed, directed to the spinal column.

Reeves and Waters (14) in 1946 reported a series of 57 cases. They also employed high-voltage radiation in quantity and quality similar to that of Tuggle and myself, directed to the spinal roots. All patients with symptoms of less than a week, with the exception of one, were free of pain. Some of the failures were believed to be due to inadequate dosage.

How roentgen rays produce analgesia in herpes zoster will be discussed later in conjunction with the other lesions in which irradiation is directed to the spinal nerve roots and peripheral sympathetic system.

MARIE-STRÜMPELL SPONDYLITIS

Roentgen therapy for the relief of pain in joint disease has long been practised

in Europe. Interest in this country was spasmodic until the publications of Smyth, Freyburg, and their associates. Their first study (15) was based on 100 cases of rheumatic disease of different types. When comparable joints were involved, one of the two was used as a control. In addition, lead screening was utilized in the majority of the cases at some period during the course of the roentgen therapy to rule out any psychic effect such treatment might engender. All patients were followed with routine interrogations and roentgenograms, sedimentation tests, etc.

The results were disappointing except in the Marie-Strümpell type of arthritis, where it was believed that the effect of roentgen therapy was certainly significant and not just temporary. It was concluded, however, that "the rationale for employment of roentgen therapy in rheumatic disease and its *modus operandi* remain to us a complete mystery." The *modus operandi* may well be a matter of opinion. The relief of pain and concomitant increase in motion which Smyth and his co-workers obtained in their cases would seem to be a logical enough basis for the employment of such therapy.

Later (16), they reported 52 cases of rheumatoid arthritis of the spine (Marie-Strümpell arthritis or *spondyliţis rhizomélique*) treated by roentgen therapy during a three-year period, with a significant degree of subjective benefit in 72 per cent and objective clinical change in 50 per cent. In this series, none of the patients protected from irradiation by lead screens showed significant improvement but, without exception, when they were later treated with roentgen rays, significant improvement occurred. In some, especially with early disease, striking relief of symptoms, particularly pain, occurred soon after the first series of treatments, and some patients with partial calcification of ligaments showed a significant increase of motion and chest expansion when the pain in the back was relieved.

The more recent experiences of Freyberg have been further confirmed and extended by Smith, Boland, Shebesta, and Hench (17), who treated 25 spondylitic soldiers with roentgen therapy alone, 25 with placebo therapy alone (lead screening being used as described above), and 25 with deep breathing and postural exercises alone. "The patients were observed in an army hospital for at least one hundred and eighty days. Of those who received therapy, subjective improvement was moderate in 56 per cent and pronounced in 36 per cent (total 92); objective improvement was moderate in 60 per cent and pronounced in 8 per cent (total 68). Of those given psychotherapy, who went through the ritual as for roentgen therapy but received no radiation, subjective improvement was moderate in 28 per cent and pronounced in 9 per cent (total 37); objective improvement was moderate in 8 per cent, pronounced in none. Of those given breathing and postural exercises alone, subjective improvement was moderate in 40 per cent and pronounced in 8 per cent (total 48); objective improvement was moderate in 32 per cent and pronounced in 8 per cent (total 40). These results are notably in favor of roentgen therapy."

The earliest group of cases (15) were treated with 200 kv., 0.5 mm. Cu and 1.0 mm. Al, 50 cm. F. S. D., 15 × 15-cm. field, receiving 200 r every other day for a total of 600 r. A like series was given twice, four to six weeks apart. The remainder of the patients were treated with similar high voltage and filtration, but only 150 r was given (200–300 sq. cm. field), repeated in forty-eight hours, for a total of 300 r. Treatment was repeated at monthly intervals as symptoms and signs warranted.

I have used similar high voltage and copper filtration with fields of 15 × 10 cm. to include the lateral ligaments in the roentgen beam, administering 200 r at a sitting, twice weekly, progressively covering the spine and then repeating the course until each part has received 1,000 or 1,200 r. All cases treated have been advanced and no improvement in mobility was noted, as might be expected, but definite relief from pain usually followed. No

leukopenia or roentgen skin changes were observed.

Relief from pain, while important, is not the whole story in the treatment of rheumatoid arthritis of the spine. Early roentgen diagnosis is quite important, as Hemphill and Reeves (18) point out, not only because early cases do better with roentgen therapy, but also the earlier the disease is recognized the more intelligent can be the orthopedic treatment.

Boyd (19) says little has been added to our knowledge of this disease since the classical paper of Marie in 1898. It is quite unrelated to ordinary osteoarthritis, and its etiology is unknown. Marie himself named it *spondylose rhizomélique* because in his cases, in addition to the spinal lesions, there was more or less complete fusion of the hip and shoulder joint.

The two lesions which dominate the picture are ossification of the spinal ligaments and bony ankylosis. The anterior spinal ligament is converted into a rod of bone which makes all movement impossible, while the other intervertebral ligaments are involved to a lesser degree. The intervertebral disks degenerate and then become ossified, so that vertebrae and cartilages form one solid mass of bone.

If the condition is related to rheumatoid arthritis, it is not too much to presume that in the early stage there is active inflammation of the synovial membrane, capsule, and surrounding soft-tissue structures, followed by destruction of the articular cartilage and the occurrence of fibrosis and ankylosis. Before fibrosis and bony ankylosis have ensued, one might attribute the relief of pain following roentgen irradiation to resolution of inflammatory products, with consequent decrease in pressure edema, but such an explanation is not tenable once the vertebrae and spinal ligaments are one fixed mass of bone.

Since, in spondylitis, all roentgen therapy is directed to the spinal column and the paravertebral area, one may reason that any effect produced will be rather well localized. In this area are the spinal cord itself, the spinal nerve roots, and the paravertebral sympathetic system. Certain symptoms described as neuralgic pains have been attributed to pressure on the spinal nerves as they pass through the intervertebral foramina, supposedly due to narrowing of the latter in the process of general ossification of the vertebrae. Yet, following irradiation, though there is relief of pain, there is no demonstrable change in the amount of ossification. Both interspinous ligaments and muscles, when injected appropriately, show definite segmental distribution of pain determined by the nerve roots involved in supplying them. Pain in the back and along the intercostal muscles is definitely relieved following irradiation. This is at least suggestive clinical evidence of the direct biological action of roentgen rays on the spinal nerve roots and the associated autonomic system.

METASTATIC BONE LESIONS

One of the satisfying experiences in radiation therapy is the relief of pain following roentgen irradiation of metastatic bone lesions. It cannot be too strongly emphasized that a patient complaining of skeletal pain following an operation for a primary metastasizing neoplasm should have roentgen therapy irrespective of "negative" roentgenograms. It is notorious that the spinal column and cord may be riddled with metastatic deposits not demonstrable by careful roentgen examination. In like situations, roentgen therapy should be begun at once.

Roentgen castration has been advocated by some as a routine in metastases from breast carcinoma because of the brilliant results that followed roentgen irradiation of the ovaries in a few cases of generalized bone metastases, but the process is not reversible. The procedure should be employed when thought indicated but, in spite of roentgen or surgical castration, metastases to bone more often than not will appear. Pain due to irritation from these metastatic foci is usually well controlled by irradiation.

High-voltage radiation should always be used with 0.5 mm Cu filtration or

more and a generous-sized field to cover the definitely localized or suspected area, at least 200 r being administered at a sitting. Such a treatment may be repeated at frequent intervals up to skin tolerance when necessary.

I recognize that the roentgen ray is not alone in relieving the pain of metastatic bone disease. At present, there is no evidence that hormones should be used to the exclusion of irradiation. I have under treatment several female patients who are receiving testosterone intramuscularly. The relief from pain and general sense of well-being that accompany its use are gratifying. However, when change of voice occurs and a beard appears, one usually has to desist. When this happens, one can still return to roentgen therapy with good results.

As Cooper and Archer (20) have well said, a patient with a controlled neoplasm, metastatic or not, is no more ready for the grave than one with controlled diabetes or a failing heart. Frequent good and occasional startling results follow adequate irradiation. Bone regeneration and relief of pain and other symptoms may ensue, with comfortable life for months and sometimes years.

MECHANISM OF RELIEF OF PAIN

How may the relief of pain following roentgen therapy be explained?

In the case of Marie-Strümpell arthritis, it has been suggested that pain was due to pressure on the spinal nerve roots due to ossification of the intervertebral foramina. But roentgenograms made after roentgen therapy and relief of pain show no change in the bony structure. In metastatic disease of the spine with collapse of a vertebra, pain is relieved following roentgen therapy long before there is demonstrable evidence of bone regeneration.

The central nervous system of the adult is generally considered relatively insensitive to x-rays. One would not expect that the x-ray dosage usually applied to the spinal area in the conditions under discussion would have a direct effect on the spinal cord or spinal nerve roots. But the effect of roentgen rays on the sympathetic system cannot be lightly dismissed. The term sympathetic is used in two senses. It is applied to the anatomical system of nerves composing the paravertebral chains of ganglia and their connections, including both afferent and efferent nerve fibers. It is also applied to a physiological system of nerve fibers having cell stations in the lateral horn cells of the spinal cord and in the sympathetic ganglia. These pre- and post-ganglionic cells and fibers constitute the efferent arc of the autonomic nervous system.

Langley (21) gave this dual system the name autonomic. We understand by the term "efferent" all nerve impulses going from cells within the central nervous system to the periphery, while "afferent" autonomic nerve fibers go from the periphery to the centers.

Langer (22, 23), writing on the roentgen rays and the autonomic system, states that the efferent system has two functions, stimulation and retardation. He claims to have influenced the autonomic nerve fibers or ganglia with roentgen rays. To prove this, he says, many animal experiments were made, the results of which showed that roentgen rays influence the sympathetic or parasympathetic nerves and a certain paralyzing effect takes place. As long as the two systems are in balance, roentgen or radium effect will not be biologically demonstrated, but as soon as the systems are out of balance, the over-irritated part will be more influenced by radiation than the other, and this is demonstrable biologically and clinically. Langer enhances his argument by reciting numerous pathological conditions which show signs of autonomic disturbances treated successfully by x-rays.

White says that sympathetic blocks relieve pain in angina (cervicodorsal) and visceral pain (splanchnic blocks) by interrupting afferent pathways. Pain relief in peripheral blocks is a different mechanism, because the sympathetics have no afferent fibers in the periphery. A theo-

retical explanation of pain relief here is: (*a*) sympathetic efferent impulses may make pain worse unless interrupted; (*b*) block gives improved peripheral circulation with corresponding decrease in pain. The foregoing suggests that the relief of pain by roentgen therapy in Marie-Strümpell's arthritis, herpes, and metastatic lesions of the spinal column is due to its effect on the autonomic system.

In estimating the relief of pain by any agent, one must not lose sight of the psychological effect. Individuals react differently. There are grades of pain. In my own experience, women bear it more graciously than men. The pain of peptic ulcer, for instance, may be relieved by appropriate medication, but may just as well be helped by a mind at ease. Accepting the idea that radiation may have a psychosomatic effect in relieving pain, the evidence at hand, at least in the conditions here considered, gainsays that it is the only or chief effect.

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SUMARIO

La Roentgenoterapia y el Alivio del Dolor

La roentgenoterapia, aplicada en tratamientos espaciados a una dosis total bien por debajo de los límites de la inocuidad, se ha mostrado efectiva en el alivio del dolor debido a estados bastante variados.

En los *diviesos* y los *furúnculos* y la llamada *bursitis subacromial* impútase el efecto de la irradiación al alivio de la tensión y a la resolución de los productos inflamatorios. En el *zona*, la *espondilitis de Marie-Strümpell* y las *metástasis cancerosas del raquis*, pasa por deberse a la acción sobre el sistema nervioso autónomo.

Al presentar su propia técnica y resultados, el A. repasa también las observaciones ajenas.

DISCUSSION

John D. Lawson, M.D. (Sacramento, Calif.): After four or five days of hearing about atoms, neutrons, electronic bombardment, various new chemicals, isotopes, and hormones, I felt this was a particularly appropriate paper given by Dr. O'Brien. He gets us back to a little clinical radiology, in which we are all interested to a considerable extent. The work is basically sound, since we all have had experiences similar to those cited by Dr. O'Brien. He dwelt on a number of subjects in which I presume his experience has been similar to that of most of us, one of which is the lack of success we frequently have in the treatment of the old, chronic herpetic patient who has had the disease for a year or two years. Here we are helpless.

Another problem which we encounter frequently is limitation of the mobility of the arm from fibrositis of the shoulder. Here, while we may relieve the pain, mobility is not restored satisfactorily without some other procedure.

Still another thing which we frequently have found disconcerting is the nausea accompanying therapy in patients with relatively active spondylitis deformans. If we pound them very hard, they frequently have to be hospitalized because of the reaction. We have had some success in a proportion of these patients through the use of cortate injections, the nausea being markedly decreased. In many cases in the acute stage, with severe pain, it was impossible otherwise to give sufficient radiation at a rapid enough rate to obtain satisfactory results. With the use of cortate we have found it possible to give enough dosage to produce the desired effect.

S. di Rienzo, M.D. (Cordoba, Argentina): In support of Dr. O'Brien's paper, I wish to emphasize the importance of irradiation in localized areas of brucellosis. As you know, brucellosis spondylitis is painful and it is difficult to relieve the pain except with large doses of morphine. We have found that 150 r daily, over a field 10 × 15 cm., with 0.5 mm. copper filter, 40 cm. distance, and 150 kv., for a total dose of 600 to 900 r per field will usually relieve the pain. The same is true with other types of infectious spondylitis, but the results are not as typical as in brucellosis.

Irradiation does not have any effect on the course of the disease but relieves pain in such a striking manner that the patient may believe he is cured. The evolution of the condition continues, however, and the focus persists.

Henry J. Ullmann, M.D. (Santa Barbara, Calif.): This is not a discussion in the ordinary sense, because Dr. O'Brien has covered the subject theoretically as well as practically. There is, however, one phase of the action of irradiation which most of us, especially in the older group, have frequently observed, *i.e.*, the analgesic effect of radiation. Many of us can remember the time when it took an appreciably heavy exposure to obtain a pelvic picture, and the patient who was suffering from a lumbago or a sciatica would occasionally experience definite relief of pain, even if it was only temporary. Dr. K. H. Thoma of Boston, a dental surgeon, told me, as far back as 1920, of the relief of tooth pain following the taking of dental films. In 1920, as many of us remember, a much larger amount of irradiation was required to get a good exposure. Regarding the dosage: I have been able to get comparable results with a total of 550 to 600 r measured on the skin (my dosage is controlled by a Victoreen Integron with the chamber in the center of the field) spread over a period of three to four weeks, depending on the number of areas or total body irradiation. This constitutes one course of treatment and is preferably not repeated for at least six weeks.

I do not feel that it is necessary to produce roentgen sickness in treating arthritis. I wish to emphasize this, as many patients have heard of such sickness and are afraid of it, as are their referring physicians. My single dose per area is usually 100 to 125 r measured on the skin, rarely 150 r. The size of this dose also depends on the number of areas treated at one sitting.

There is a question which I should like to ask Dr. O'Brien. It concerns the problem of affecting the ovaries in younger women, when the lumbosacral region is treated. I should like to know if and how an ovarian effect can be avoided.

While the progress of an osteo-arthritis is not influenced, the pain in a large proportion certainly is affected by small doses. I am inclined to lay this effect to two possible things, a temporary slowing of any inflammatory process present and a definite analgesic effect of the irradiation. The great difficulty is preventing the continual return of patients for further relief.

F. T. Gassman, M.D. (Los Angeles, Calif.): I would like to ask Dr. O'Brien whether he considers immobilization of the shoulder joint in cases of bursitis of importance during and after the treatments.

Dr. O'Brien (*closing*): In reply to the last question, immobilization is extremely important. We generally advise the patient, especially if it is an "acute shoulder," to put it in a sling and carry it in one until he or she gets relief.

Regarding Dr. Ullmann's question, I have never treated an early spondylitis of the Marie-Strümpell type.

Dr. Ullmann: Not that. I meant a rheumatoid arthritis—a beginning arthritis.

Dr. O'Brien: I have treated only the advanced Marie-Strümpell type of arthritis.

Studies in the Scope of Pneumoarthrography of the Knee as a Diagnostic Aid[1]

MAURICE D. SACHS, M.D., WILBERT H. McGAW, M.D., and RUSSELL P. RIZZO, M.D.
Cleveland, Ohio

THE CLINICAL diagnosis of the wide diversity of diseases and injuries of the knee has serious limitations. A review of the literature shows that its accuracy varies from 70 to 75 per cent. Unfortunately, in the past, roentgenographic diagnosis based on routine films has made only a minimal contribution in meniscal lesions (14, 29, 33). It has proved of definite value, however, in advanced degenerative arthritis, fractures, osteochondritis dissecans, and joint mice (4, 27, 33, 37).

Changes of the joint space as shown on routine films are of questionable significance for the diagnosis of meniscal derangements. Obvious narrowing, with or without irregularity, is indicative of articular cartilaginous destruction. Degenerative arthritis and adjacent soft-tissue lesions may be manifested by osteophytic lipping, eburnation, or irregularity. Unusual separation of a joint space may be due to a torn or relaxed ligament or a meniscal cyst; in the latter instance, however, there is also an increased soft-tissue density. Evans (17) stated that if comparison films of the knees were taken, they would show sclerotic changes of the involved condyle which are suggestive of a meniscal lesion. Sclerosis of the patella may suggest the possibility of an osteochondrosis. Experience has taught that careful observation of adjacent soft-tissue may indicate suspected pathological changes. For example, soft-tissue masses in the region of the capsular pouches may be due to hematoma, fluid, synovial thickening (due to tuberculosis or other infection, or to trauma), or rupture of the patellar tendon.

The revived interest and recent developments in pneumoarthrography by Andersen (1), Brooke *et al.* (10), Butts and Mitchell (12), Hamilton (19, 20), Somerville (53), and others (7, 8, 21, 25, 30, 42, 43, 47, 48, 49, 50, 52), lead us to believe that the previous objections to the procedure, such as inadequate diagnostic films and post-media sequelae, have been eliminated. As early as 1904, Werndorff and Robinson (57) were reporting on the relative value and use of pneumoarthrography of the knee. Wollenberg (58) and Hoffa (22) followed in 1906 with further studies. Since then, many radiopaque and radiotranslucent substances have been tried in an effort to find an acceptable, safe, suitable contrast substance (9, 13, 28, 34). It is apparent that the following criteria should be used in determining the desirability of a given medium: (1) high safety factor; (2) minimum of irritation and reaction; (3) production of a diagnostic film; (4) rapid absorption.

Use of an opaque medium for contrast has had many advocates, chief among whom have been Bircher (5) and Oberholzer (45). The substances used include such iodine compounds as lipiodol, abrodil, sodium and potassium iodide solutions (arthropsin, hippuran, skiodan), etc., alone or in combination with oxygen or air (5, 6, 26, 35, 36, 51, 54). The use of these media has been criticized on the ground (1) that they obscure bone detail or loose bodies; (2) that they are absorbed slowly and cannot always be removed completely, and therefore give rise to irritation, foreign-body reactions, and adhesions; (3) that they may cause a flare-up of an old infec-

[1] From the Radiological and Orthopedic Services, Western Reserve University School of Medicine and Crile V. A. Hospital, Cleveland, Ohio. Presented at the Thirty-fourth Annual Meeting of the Radiological Society of North America, San Francisco, Calif., Dec. 5–10, 1948. Published with permission of the Chief Medical Director, Department of Medicine and Surgery, Veterans Administration, who assumes no responsibility for the opinions expressed or conclusions drawn by the authors.

tion (11, 28, 32). Jepson (24), moreover, reported several instances of myositis ossificans following the use of lipiodol. All of the above media produce varying degrees of deleterious reaction in a joint.

Oxygen as a contrast medium has many more advocates and it is our medium of choice (1, 2, 22, 40, 55–58). Commercial oxygen has been found to be relatively dust-free and sterile in culture media; it is non-irritating and is absorbed more rapidly than air. Bernstein and Arens (3) found carbon dioxide equally satisfactory.

In the past, fear of embolism discouraged many potential investigators from using air or oxygen. This was primarily due to two instances reported in 1907 by Jacobsohn and Holzknecht (Jacobsohn, 23). In the first case, oxygen was used, and in the second, air. Wollenberg, Hoffa, Strater and others, who took part in the discussion of Jacobsohn's report, stressed the fact that if direct entry into a vessel were avoided, oxygen could be injected into the body with impunity. Since 1907, several thousand injections have been done, with only one instance of pulmonary embolism, non-fatal, reported by Kleinberg (31) in 1927. It was Kleinberg's conviction that in that case the technic of injecting the oxygen, rather than the procedure itself, was at fault. In all probability, the oxygen was administered, inadvertently, directly into a vessel, with the needle connected to an oxygen tank.

The only theoretical contraindications to pneumoarthrography are: (1) the danger of emboli in acute intra-articular fractures, where there may be torn veins; (2) the danger of spreading infection in the early stages of suppurative arthritis.

The roentgen technic of pneumoarthrography has not progressed until recently, inasmuch as earlier authors were concerned with the diagnosis of synovitis, hypertrophy of the fat pad, or tears of the cruciate ligaments. Consequently, each developed a limited technic that satisfied his respective needs. In many instances additional pertinent pathological changes were not diagnosed.

Dittmar (16) in 1932, Evans (17), 1940, Gershon-Cohen (18), and others (39, 41) were able to demonstrate the menisci by use of forceful extension and abduction, the so-called vacuum technic. The menisci were not demonstrable in the presence of fluid. Nordheim (44) in 1938 followed up Dittmar's work and in the presence of fluid injected oxygen. Thus it may be said that Nordheim was one of the originators of the technic now used in pneumoarthrography.

Cullen and Chance (15) and Somerville (53) reported excellent results with fluoroscopic study of the joint, together with oblique views. They, too, as well as McGaw and Weckesser (40), Meschan and McGaw (41), and Möhlmann and Madlener (42) stressed the value of spreading the joint by manual or mechanical means to bring both surfaces of the menisci into profile view. Some investigators (38, 42) have advised the use of elastic bandages over the suprapatellar region; others (38, 45, 54) have advocated flexing the knee in order to spread the oxygen through the joint. We have found that films taken in the postero-anterior projection best visualize the menisci by enabling any residual fluid in the joint to gravitate into the suprapatellar pouch. In addition, for adequate diagnostic films, the x-ray beam should be perpendicular to the joint; there should be forcible spreading of the joint, and multiple oblique views should be taken.

We believe, therefore, that the following criteria are essential for comprehensive and accurate diagnoses in pneumoarthrography: (1) all projections postero-anterior; (2) fluoroscopy of the knee joint to assure proper centering of the x-ray beam through the joint; (3) forcible spreading of the joint to visualize both surfaces of the menisci; (4) multiple oblique views for adequate visualization of the menisci.

The studies reported here are a continuation of previous work, started by McGaw and Weckesser in 1942 (40) and continued by Meschan and McGaw (41) up to 1946.

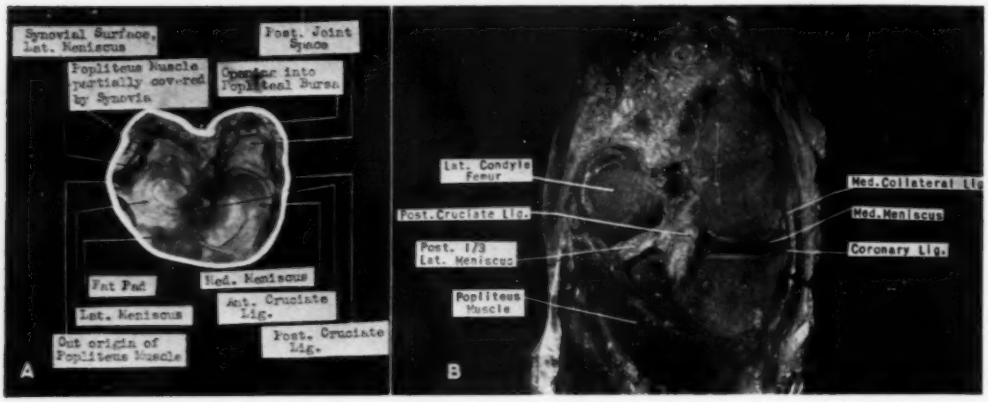

Fig. 1. A. Anatomy of the knee joint. (Reproduced by courtesy of J. Bone & Joint Surg.)
B. Posterior oblique coronal section of left knee in internal rotation: postero-anterior view, showing posterior tip of lateral meniscus and cross section through posterior insertion of medial meniscus.

FUNCTIONAL ANATOMY OF THE KNEE

The knee is the largest weight-bearing joint in the body, both in regard to its area of articular cartilage and in its synovial capacity. This shallow, double-hinged joint is located between the two largest and strongest bones in man. The knee, like the back, has assumed a new role in our upright position of standing, walking, and running. The patella, the largest sesamoid bone, also forms a sliding joint with the femur.

The weight-bearing portions of the knee are protected by two semilunar cartilages or bushings (Figs. 1 and 2). The menisci deepen the sockets of the tibial condyles or plateau. Two strong intracapsular cruciate ligaments and two extracapsular collateral ligaments protect the joint.

Being an exposed joint between the two longest bones, the knee is vulnerable both to direct and to indirect angular and torsional strains and stresses, thus accounting for the high incidence of ligamentous and meniscal injuries common to those engaged in sports, in some industries, and in military duty.

The medial meniscus is "C" shaped, semicircular in form, and attached at its two horns to the tibia by ligaments. Its inferior periphery is attached to the tibia by the coronary ligament. The remainder of the base of the meniscus is intimately fused through the capsule to the inner portion of the medial collateral ligament. It thus has a simple and complete encircling attachment (Figs. 1 and 2).

The lateral meniscus is "O" shaped or nearly circular. Although the lateral meniscus is similarly attached, it has no peripheral attachment to the joint capsule where the popliteus tendon muscle crosses it obliquely (Figs. 1 and 2B).

When seen in cross section, the meniscus appears as a wedge of triangular shape attached at its base, with a free inner margin (Fig. 2).

The normal potential capacity of the synovial cavity is 80 to 120 c.c. It is incompletely divided into an anterior and two posterior joint sacs as well as a large suprapatellar pouch. One or more popliteal bursae may communicate with the knee joint. The infrapatellar fat pad, normally covered with synovia (Fig. 3), fills the triangular space between the anterior condyles of the femur and tibia and the under surface of the patellar tendon. It is frequently traumatized and pinched. Loose areolar fat adjacent to the synovia may also be found in the floor of the suprapatellar pouch These fatty areas of the synovia are thought by Kling (32) and some investigators to produce the mucin of the synovial fluid.

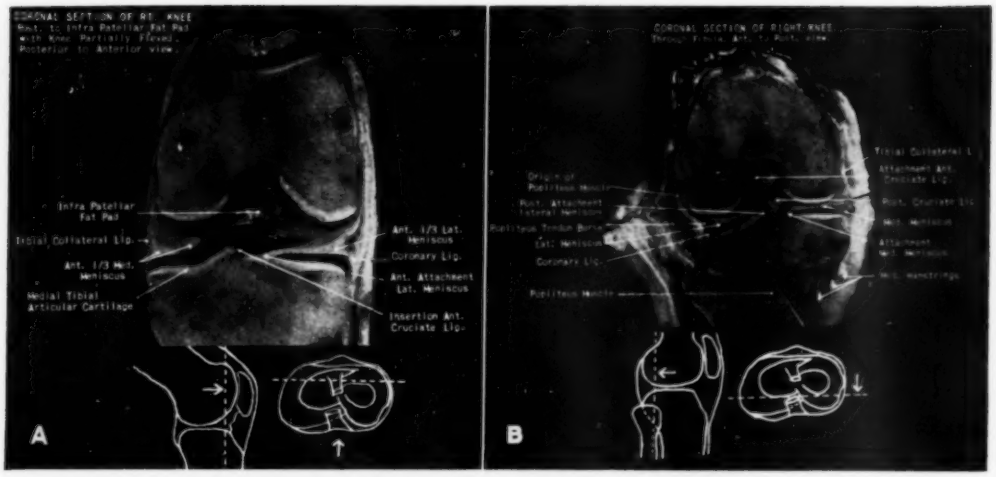

Fig. 2. A and B. Coronal sections of right knee.

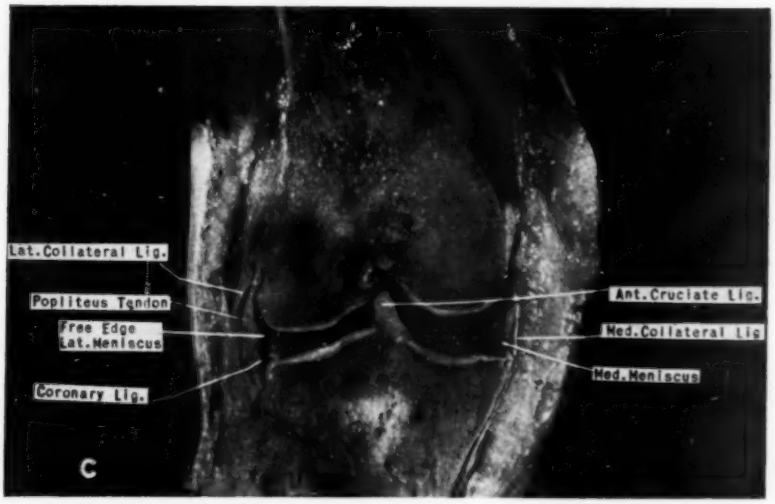

Fig. 2. C. Oblique coronal section of left knee, with knee in internal rotation, through tibiofibular joint. Postero-anterior view showing anterior third of medial meniscus and posterior third of lateral meniscus. Note (1) free superior edge of lateral meniscus and popliteal bursa; (2) loose attachment of medial meniscus.

OXYGEN INFLATION TECHNIC

Sedation is not required for oxygen inflation. The knee, carefully shaved and cleansed with antiseptics, is draped with sterile towels. Strict aseptic technic is followed. Through a small 20- or 22-gauge needle, procaine is infiltrated in a skin wheal, then deeper into the capsule and synovia until the joint is entered under the patella. This may be done from either the lateral or medial side. The patella is pushed toward the side of injection to localize the sulcus between the patella and femur. Any excess fluid is aspirated. Oxygen is gently injected into the joint by an ordinary syringe until the synovia becomes distended and the patient complains of fullness and discomfort in the knee (80

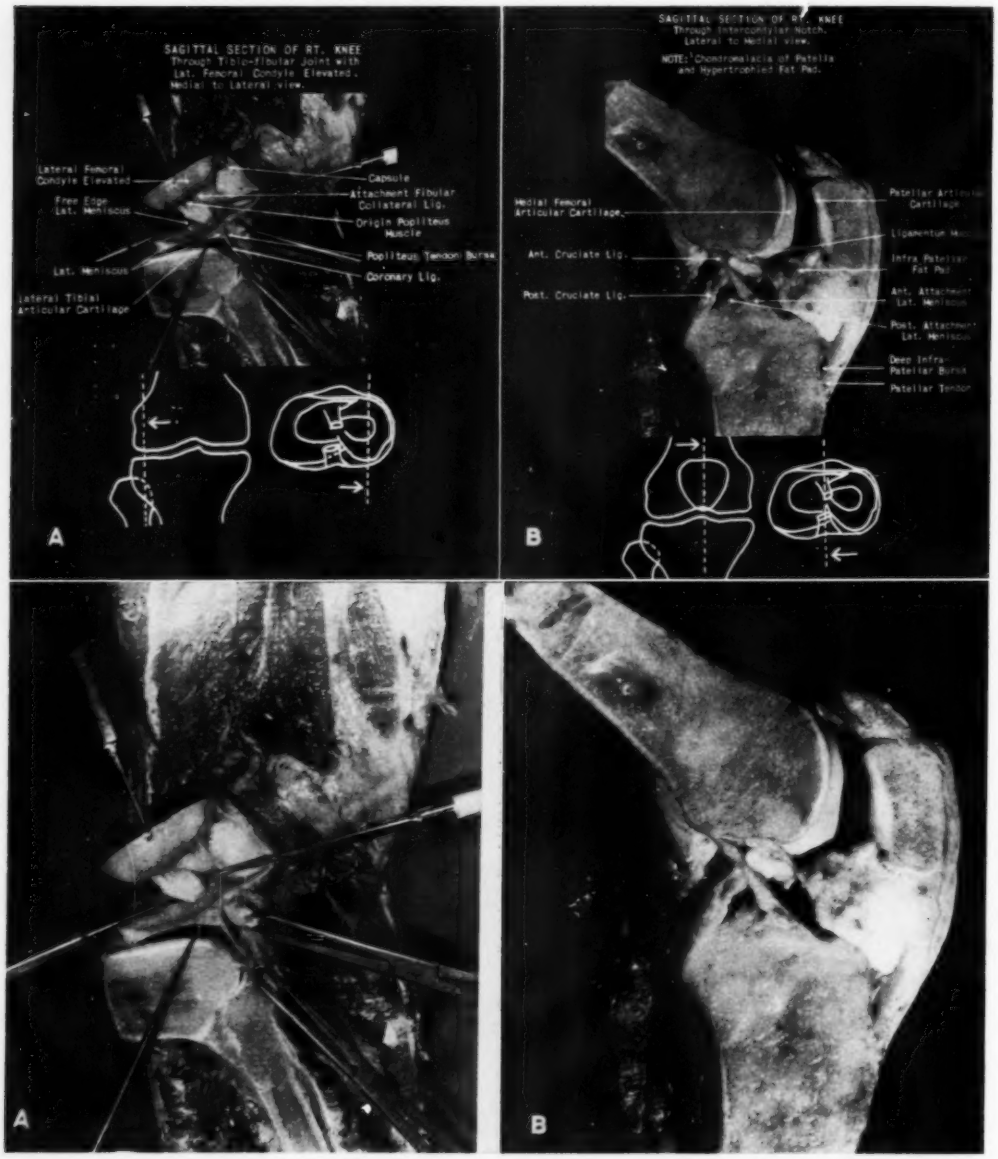

Fig. 3. A. Sagittal section, right knee, through tibiofibular joint with lateral femoral condyle elevated, showing popliteus tendon. Medial to lateral view.

B. Sagittal section, right knee, through intercondylar notch and patella, lateral to medial view, showing cruciate ligaments, enlarged fibrotic fat pad, and chondromalacia of patella.

to 120 c.c. for an adult male is sufficient). In all such procedures, care must be taken to prevent the injection of oxygen directly into a vein. Multiple needle punctures of the synovia, which allow oxygen to enter the interstitial tissue, should also be avoided. The amount injected is recorded, inasmuch as it is indicative of the joint capacity, which may be decreased in certain types of arthritis, quadriceps adhe-

sions, and chronic synovitis, or increased in neurarthropathy.

Undue pressure is unnecessary, and the degree of inflation should depend entirely on the comfort of the patient. Moreover, excess pressure tends to cause leakage. Incidentally, there is never leakage of oxygen through the skin. As the needle is removed, a finger is firmly held pressed to the puncture hole for several seconds until it seals off. This prevents subcutaneous emphysema, which, in itself, is not dangerous but produces extraneous shadows which spoil the pneumoarthrogram. (If extraneous shadows are present, the procedure should be repeated at a later date.) The patient is then turned on his abdomen and encouraged to flex the knee gently. The latter procedures allow any residual fluid around the menisci to gravitate into the suprapatellar pouch and the oxygen to spread throughout the joint cavity. The patient is then ready for roentgenography.

ROENTGEN TECHNIC

Best results are obtained when the personnel involved in this procedure understand the importance and absolute necessity of the following points: (1) proper localization of the joint space; (2) spreading of the alternate joint spaces; (3) enough views to permit visualization of all parts of the involved joint; (4) technical factors which produce maximum soft-tissue and bone detail.

1. *Localizing the joint* is the first important step and is best done by means of fluoroscopy. The skin is marked in the popliteal space over both the medial and lateral joint spaces. This is done so that the central ray will be perpendicular to the joint space or parallel to the top of the tibial plateau, thereby preventing overlapping of bone structure and obliteration of the meniscus shadow.

2. *For spreading the joint spaces*, a mechanical device of simple design should be provided. This step may be accomplished manually by a bar held by a technician or by using the equipment as illustrated, which is a standard accessory of all

Fig. 4. A. Diagram illustrating multiple routine roentgen projections and profile views of menisci.
B. Demonstration of medial joint spread with foot in neutral position and postero-anterior projection. (Cassette used for photographic demonstration.)

x-ray units (Fig. 4B). A shoulder rest is set into slots along the edge of the table for stability and used as a fulcrum, while the thigh and ankle are pulled or levered apart by the two ratchet tighteners. If the shoulder rest is too short, an extension piece of 6 to 8 inches may be soldered onto it.

3. *Seven views are taken routinely*—all except the lateral in the postero-anterior projection (Fig. 4A). The anteroposterior

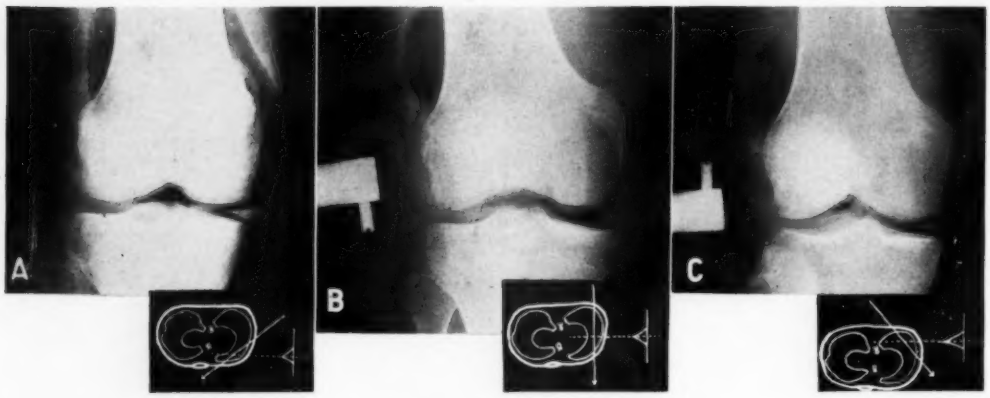

Fig. 5. Normal medial meniscus.

A. Anterior oblique view (marked internal rotation of extremity) with medial joint spread, showing profile of anterior third of medial meniscus. Note oval diamond appearance due to recesses at base. The articular cartilage is smooth and follows the condylar outline. Note suprapatellar pouch.

B. Straight postero-anterior view (mid-position of extremity) with medial joint spread, showing profile of medial meniscus. Note overlapping appearance of posterior third of meniscus behind middle third.

C. Posterior oblique view (marked external rotation of extremity) with medial joint spread, showing profile of posterior third of medial meniscus.

projection has been discarded, as in that projection the meniscus may be obscured by excess joint fluid.

A. Three views are taken with the medial joint spread (Fig. 4):
   (*a*) Internal rotation position, *i.e.*, foot inverted (profile view of anterior third of the meniscus is obtained) (Figs. 2 and 4).
   (*b*) Neutral position, *i.e.*, foot pointed down (profile view of middle third of the meniscus is obtained) (Figs. 2A and 4).
   (*c*) External rotation position, *i.e.*, foot everted (profile view of posterior third of meniscus is obtained) (Figs. 2B and 4).

B. Three views are taken with the lateral joint spread (Fig. 4):
   (*d*) Foot inverted (posterior third of meniscus is seen) (Figs. 2 and 4).
   (*e*) Neutral position, *i.e.*, foot pointed down (middle third of meniscus is seen) (Figs. 2A and 4).
   (*f*) Foot everted (anterior third of meniscus is seen) (Figs. 2 and 4).

C. One lateral view is taken without spreading (Fig. 3):
   (*g*) Lateral view (suprapatellar, anterior and posterior joint pouches, popliteal bursae, fat pad, articular surfaces, patellar tendon, and cruciate ligaments are seen).

4. *To assure good soft-tissue and bone detail*, all exposures are made by using cardboard holders with fast-speed film, Potter-Bucky diaphragm, extension cone, target-film distance of 36 inches, 72–80 kv., 200 ma., and an exposure of one second.

NORMAL PNEUMOARTHROGRAMS

Pertinent structures seen in pneumoarthrograms are the menisci, synovial sacs, infrapatellar fat pad, cruciate and collateral ligaments, and articular cartilages. Each may best be seen in a given view.

Menisci: The medial meniscus is best seen with the medial joint spread. Its profile shadow is a sharp, well demarcated triangular density clearly outlined by oxygen above and below (Fig. 5). Its base is firmly attached to the capsular and tibial collateral ligaments. The apex is always on a horizontal plane, lying free between the femur and tibia. As a rule, the apex of the anterior third of the medial meniscus extends to less than one-third of the weight-

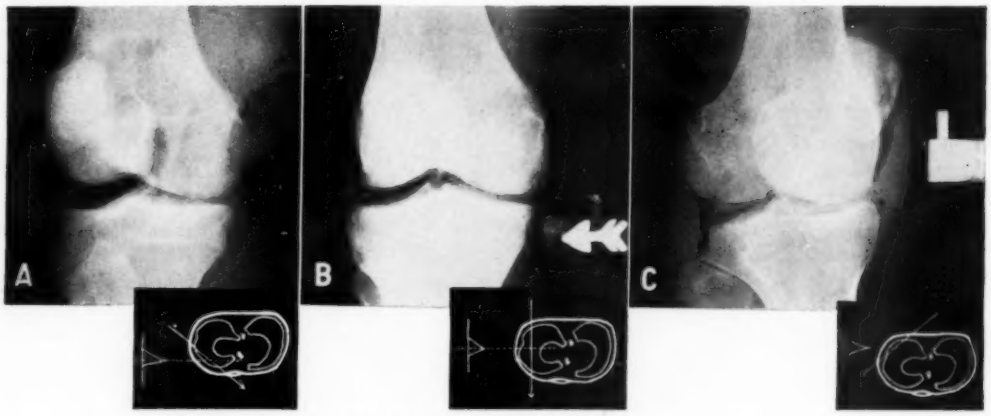

Fig. 6. Normal lateral meniscus.

A. Anterior oblique view (marked external rotation of extremity) with lateral joint spread, showing profile of anterior third of lateral meniscus. In this view the meniscus in profile is anterior to the popliteus tendon and bursa. Note tapering of lateral meniscus to middle of femoral condyle.

B. Straight postero-anterior view (mid-position of extremity) with lateral joint spread, showing profile of middle third of lateral meniscus with overlying shadow of popliteus tendon.

C. Posterior oblique view (marked internal rotation of extremity) with lateral joint spread, showing profile of posterior third of lateral meniscus. In this view the popliteus bursa simulates a fracture through the base of the lateral meniscus, but is a normal finding. Note popliteus tendon bursa and coronary ligament.

bearing surface of the femoral condyle, the middle third to slightly more than one-third, and the posterior third to slightly less than one-half. The appearance of the meniscus varies with the individual knee and the degree of rotation. Its shadow is smallest when the foot is inverted (anterior third) (Fig. 5A) and largest and thickest when the foot is everted (posterior third) (Fig. 5C).

The lateral meniscus is best visualized with the lateral joint space spread. The base of the meniscus is not as completely attached to its capsular and collateral ligaments as is the medial meniscus. The lateral meniscus in profile is thinner than the medial (Fig. 6). Its appearance is almost that of an isosceles triangle, whereas the medial more closely simulates an equilateral triangle. The apex extends to or slightly beyond the center of the weight-bearing surface of the femoral condyle.

With the foot everted, the anterior third of the lateral meniscus is seen in profile as a long, thin, tapering, elliptical density, its apex ending almost at the middle of the weight-bearing surface of the femoral condyle (Fig. 6A). With the foot in a neutral position, the middle third of the lateral meniscus is seen in profile as a thin, long, tapering, triangular shadow, its apex, slightly shorter than the anterior third (Fig. 6B). With the foot inverted, the posterior third of the meniscus appears slightly thicker than the anterior third, tapering, and its apex as long as the middle third (Fig. 6C). In this last view, in almost all instances, the popliteus tendon is seen as an oblique, linear area of increased density at the base of the meniscus (Figs. 6B and 9C). The popliteus tendon bursa, which is the space between the tendon and the base of the meniscus, is seen as a rarefaction and may be misinterpreted by the inexperienced as a meniscal tear (Fig. 6C).

Variations of Normal Menisci: Anatomical and surgical observations have proved that the difference in size and configuration of the menisci as seen in pneumoarthrograms is, to a great extent, determined by the degree of rotation of the extremity.

Small indentations may be observed at either the superior or inferior base of the menisci, or at both (Fig. 5A). It is thought that the superior recesses are due to a fusion of soft synovia with firm cartilage. Consequently, the meniscus is some-

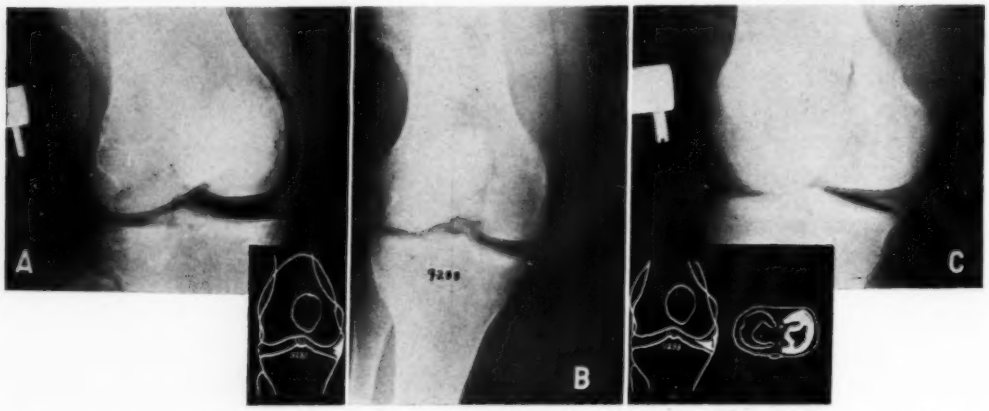

Fig. 7. Value of oblique views in visualizing meniscal pathology.

J. G., 21 years. Right knee. Football. Pain, swelling, and repeated locking. Rt. quad. 1"; no fluid; motion 180/55; no crepitus; anterior medial tenderness; stable joint. *Clinical diagnosis:* Fracture dislocation of medial meniscus.

A. Medial oblique view. Anterior third of meniscus (foot inverted). Note short irregular segment of anterior third of the medial meniscus, indicating a fracture-dislocation.

B. Middle third of meniscus (foot neutral), irregular, blunt, with fragment displaced in the intercondylar notch.

C. Posterior third of meniscus (foot everted). Incomplete superior longitudinal tear at the base of posterior third of the meniscus. *Pneumoarthrographic diagnosis:* Fracture-dislocation of medial meniscus with secondary posterior laceration at base.

Operative findings: Fracture-dislocation and secondary posterior longitudinal laceration.

what thicker in its center and assumes an oval or diamond shape. Sometimes its shadow appears to be double-imaged. This is due to the saucer-like configuration or tilting of the meniscus, with one edge, usually the posterior third, slightly higher than the anterior (Figs. 2A and 5B). The popliteus tendon shadow is seen at the base of the posterior third of the lateral meniscus (Figs. 1, 6B, and 9C). Sometimes its obliquity varies slightly so that the shadow is observed more toward the middle of the meniscus. This depends on the degree of rotation of the extremity.

Articular Surfaces: The femoral and tibial articular cartilages follow the bony outline of the condyles and present a smooth border of increased soft-tissue density approximately 2 mm. thick, which is best seen with spread of the respective medial or lateral joint (Figs. 5A, 6B). The patellar articular cartilage appears as an ncreased soft-tissue shadow following the contour of the patella. It is best seen with the knee fully extended. If a film is taken with the knee in partial flexion (15–30°), the femoral condyle overlaps and partially obscures the patellar cartilage (Figs. 3 and 12A).

Synovial Spaces: The suprapatellar pouch, in the postero-anterior film, is visualized on either or both sides of the femur, extending up the shaft for a distance of 4 to 6 cm. The synovial outline of its walls is relatively smooth and thin (Fig. 5A). The two posterior pouches (one for each femoral condyle) are small, circular, and appear to overlap in the lateral view (Fig. 12A). They roughly divide the anterior and posterior joint spaces. In the postero-anterior view they fill the space between the tibial spine and intercondylar space but are not well outlined. In 10 to 15 per cent of the cases, the posterior pouches communicate with one or more popliteal (Baker's cyst) bursae. Only a small number of these are symptomatic. The suprapatellar pouch, in the lateral view, is seen as an oval rarefaction, slightly bulging superiorly under the quadriceps mechanism and narrowing inferiorly at the femoropatellar articulation. The floor of the pouch conforms to the anterior surface of the femur, with loose areolar tissue. A

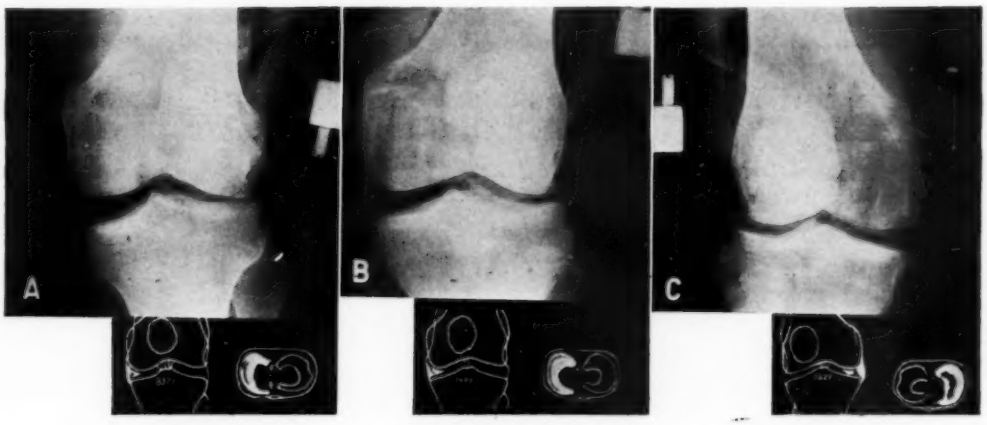

Figure 8.

A. Dual longitudinal lacerations of medial meniscus. Note markedly irregular defects in inferior surface at base of medial meniscus.

C. S., 23 years. Left knee. Basketball. Pain, swelling, repeated locking. *Physical examination:* Lt. quad. $-3/4''$; no fluid; motion 180/40; no crepitus; anterior medial tenderness; instability, anterior cruciate $++$, medial $+$. *Clinical diagnosis:* Fracture of medial meniscus; rupture of anterior cruciate and medial collateral ligaments. *Pneumoarthrographic diagnosis:* Fracture of medial meniscus. *Operative findings:* Dual longitudinal lacerations of medial meniscus.

B. Longitudinal fracture of medial meniscus, with minimal displacement. Note (1) irregular diagonal defect through base of medial meniscus; (2) hypermobility of the lateral meniscus on abduction and squeezing-out effect by the condyles, illustrating mechanism of meniscal tears.

M. R., 33 years. Left knee. Calisthenics. Pain, repeated locking, swelling. *Physical examination:* Rt. and lt. quad. equal; no fluid; motion 180/40; crepitus $+$; anterior medial tenderness; instability, anterior cruciate, $++$. *Clinical diagnosis:* Fracture of medial meniscus; rupture of anterior cruciate ligament. *Pneumoarthrographic diagnosis:* Longitudinal fracture of medial meniscus with minimal displacement. *Operative findings:* Longitudinal fracture of medial meniscus with minimal displacement.

C. Fracture of posterior third of medial meniscus with partial displacement. Posterior oblique view showing irregular blunted defect through body of medial meniscus with slight displacement of inner portion.

A. C., 25 years. Right knee. Fell while running. Pain, swelling, repeated locking. *Physical examination:* Rt. quad. $-1''$; fluid $+$; motion 180/35; crepitus $+$; marked medial and subpatellar tenderness; instability, anterior cruciate, $++$. Positive compression test. *Clinical diagnosis:* Fracture of medial meniscus; rupture of medial collateral and anterior cruciate ligaments; chondromalacia of patella. *Pneumoarthrographic diagnosis:* Fracture of medial meniscus. *Operative findings:* Fracture of medial meniscus with partial displacement.

thin plica invariably traverses the pouch obliquely. It extends from the floor to just above the upper margin of the patella (Fig. 6A).

The infrapatellar joint space is almost filled by a fat pad which is roughly triangular in shape, with its broad base attached to the patellar tendon. A somewhat loculated apex of the fat pad is directed posteriorly toward the intercondylar notch. The ligamentum mucosum, if present, can be seen as a thin, hair-like, soft-tissue shadow extending from the apex of the fat pad superiorly and posteriorly toward the intercondylar notch (Fig. 12A). The cruciate ligaments are seen as an inverted V-shaped density in the mid-posterior portion of the joint (Figs. 3B, 12A).

DIAGNOSIS

An early accurate diagnosis is the cardinal requisite for specific therapy. All diagnoses are based on subjective and objective findings. Pneumoarthrography furnishes a host of objective findings unobtainable by any other means.

Before describing the pathological pneumoarthrogram, consideration should be given to the various lesions commonly referred to as "internal derangements of the knee," and to those lesions which may simulate them.

I. Internal derangements
   A. Semilunar cartilage lesions
      1. Ruptures, dislocations
      2. Combined with ligament injuries
      3. Combined with arthritis
      4. Cystic and discoid menisci

B. Loose bodies
C. Contusions, sprains, ligament ruptures
   1. Traumatic synovitis
   2. Hemarthrosis

II. Conditions simulating internal derangements
A. Inflamed bursae or cysts
B. Fractures: intra-articular
C. Arthritis: acute and chronic
D. Tumors: bone, cartilage, synovia, etc.

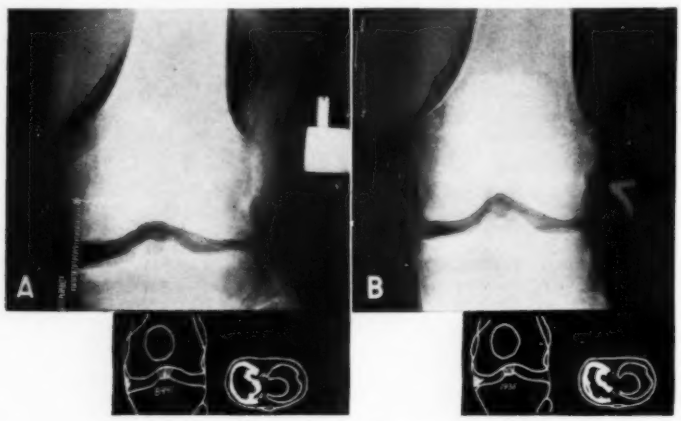

Figure 9.

A. Bucket-handle fracture of medial meniscus. Note (1) irregular shortened base with absence of major portion of medial meniscus; (2) subcutaneous emphysema.

A. E., 27 years. Left knee. Football. Pain, swelling, recurrent locking, "slipping out." *Physical examination:* Lt. quad. −1/2"; no fluid; motion 180/35; no crepitus; anterior medial tenderness; instability, anterior cruciate, +. *Clinical diagnosis:* Fracture of medial meniscus; rupture of anterior cruciate ligament. *Pneumoarthrographic diagnosis:* Fracture-dislocation of medial meniscus (bucket-handle fracture). *Operative findings:* Bucket-handle fracture of medial meniscus.

B. Fracture-dislocation of medial meniscus. Note short irregular base and smooth tip of medial meniscus, with displaced portion in intercondylar notch.

J. U., 31 years. Left knee. Baseball. Pain, swelling, repeated lockings. *Physical examination:* Lt. quad. −1/2"; no fluid; motion 180/40; no crepitus; medial tenderness; stable joint. *Clinical diagnosis:* Fracture of medial meniscus. *Pneumoarthrographic diagnosis:* Fracture-dislocation of medial meniscus. *Operative findings:* Fracture-dislocation of medial meniscus with anterior detachment.

THE PATHOLOGICAL PNEUMOARTHROGRAM

The Menisci

Any deviation from the normal sharply outlined triangular shadow of the meniscus or its substance as previously described is indicative of a meniscal lesion. These deviations may be represented by a change in the size of the meniscal shadow, which is either too large or too small; a change in shape—irregular, serrated, or fragmented; or any combination of these. The following are lesions commonly seen in the pneumoarthrogram:

(1) *Incomplete fracture* is seen as a linear area of rarefaction or "crack" extending from either meniscal surface into the body but not through it (Figs. 7C, 8A). The rarefaction may be vertical, horizontal, oblique, or any combination of these.

(2) *Complete fracture without dislocation* is represented by a similar area of rarefaction which extends from one surface to the other, completely through the substance of the meniscus. There may be multiple tears, with many fragments. These, however, are all seen and are in apposition.

(3) In *complete fracture with dislocation* the picture is similar to that in the complete fracture without dislocation except for the absence of one or more fragments; commonly, these include the apical fragment. These fragments may be completely dislocated into the intercondylar notch and may not be discernible in the pneumoarthrogram (Figs. 9A, B, C), the

so-called "bucket-handle" fracture-dislocation. In such instances the basal remnant may be short, blunt, irregular, or serrated, or it may appear as a small, smooth, equilateral triangle. This triangular shadow could represent the long standing remnant of a bucket-handle fracture or the regeneration of a previously excised meniscus (Fig. 9D).

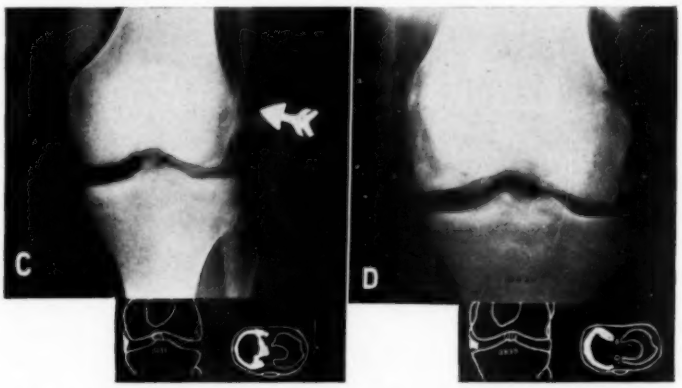

Fig. 9. C. Fracture-dislocation of medial meniscus. Note (1) absence of apical portion of medial meniscus, with remaining short blunted base; (2) apical segment displaced in intercondylar notch; (3) shadow of popliteus tendon at side of joint.

B. S., 22 years. Left knee. Basic training. Pain, swelling, difficulty in marching, no locking. *Physical examination:* Lt. quad. $-1''$; fluid $+$; motion 180/40; no crepitus; anterior medial tenderness; lateral instability $+$. *Clinical and pneumoarthrographic diagnosis:* Fracture-dislocation of medial meniscus. *Operative findings:* Fracture-dislocation of medial meniscus.

D. Previous surgical excision of medial meniscus with marginal remnant, closely simulating the bucket-handle tear type with dislocation. Note (1) that medial meniscus is short and not pointed, that the apex is absent and the inner margin squared; (2) arthritic changes.

M. G., 27 years. Right knee. Fall of 15 feet. Pain, swelling, weakness. Four operations for loose bodies and excision of medial meniscus. *Physical examination:* Rt. and lt. quads. equal; fluid $++$; motion 170/60; crepitus $+++$; generalized tenderness; stable joint. *Clinical diagnosis:* Osteochondritis dissecans with loose bodies; surgical removal of medial meniscus. *Pneumoarthrographic diagnosis:* Surgical removal of medial meniscus; chronic arthritis. *Operative findings:* Marginal remnant of medial meniscus; chronic arthritis and synovitis; loose cartilaginous body in anterior joint.

Multiple oblique views of the knee have been the decisive factor in establishing the specific location as well as the extent of the meniscal lesion. The appropriate surgical incision thus can be planned. In some instances a diagnosis can be made of any combination of fractures or tears in the same meniscus or in the two menisci of the same knee which were not suspected clinically. In this series there were 9 cases of bilateral meniscal tears in the same knee. Such findings have enabled the surgeon to treat all the existing pathological changes at one operation.

(4) *There are a number of less common abnormalities.* (*a*) *Meniscal cysts* (Fig. 10D) occur in the lateral meniscus. In appearance, they vary in thickness and their contour at the base is broad, bulging, somewhat circular, showing no evidence of a tear. Saccular rarefactions within the meniscus are evidence of multilocular cysts. In this series, cysts have not been observed in the medial meniscus.

(*b*) A *discoid meniscus* (Fig. 10E) appears as a disk or plate-like structure occupying almost all of the intra-articular joint space, with its apex extending past the center of the femoral condyle to, or almost to, the intercondylar notch. Although this is a developmental anomaly, it usually becomes symptomatic when fraying, fracture, or degeneration occurs.

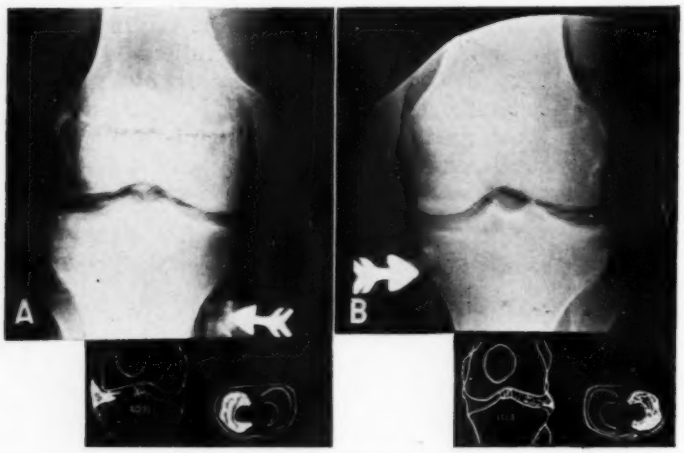

Fig. 10. Pathological changes in lateral menisci.

A. Longitudinal fracture. Note the irregular cleft apical portion of the lateral meniscus, chiefly involving the tibial surface.

A. B., 22 years. Right knee. Jumped from truck. Pain, swelling, inability to march. *Physical examination:* Rt. quad. $-1/2''$; fluid +; motion 180/45; crepitus +; medial tenderness; stable joint. *Clinical diagnosis:* Fracture of medial meniscus. *Pneumoarthrographic diagnosis:* Longitudinal fracture of tibial surface of lateral meniscus. *Operative findings:* Irregular longitudinal laceration of lateral meniscus. The superior (femoral) surface appeared smooth.

B. Fragmented lateral meniscus. Note marked shredding of lateral meniscus, with displacement of numerous fragments.

F. S., 33 years. Right knee. Jumped from truck. Pain, snapping, swelling, recurrent locking. *Physical examination:* Rt. quad. $-1''$; no fluid; crepitus ++ (audible); anterior lateral tenderness; motion 180/40; stable joint. *Clinical diagnosis:* Fracture of lateral meniscus. *Pneumoarthrographic diagnosis:* Multiple lacerations of lateral meniscus. *Operative findings:* Marked fragmentation of lateral meniscus.

(*c*) A "*hypermobile meniscus,*" which has been questioned as an entity, is suggested by a normal meniscus which has an unusually wide range of mobility, associated with relaxation of collateral and coronary ligaments. The meniscus may shift from the intercondylar notch region out of the joint space entirely. Further investigation of this problem is being carried out at the present time.

Loose Bodies

Loose, non-calcified bodies, ordinarily not seen in routine films, are demonstrable in profile views by the contrast effect of the surrounding oxygen. Calcified bodies are clearly seen. The anatomical localization and number of these loose bodies are easily discernible (Fig. 14A, B). It is also possible to determine whether opaque foreign bodies are within or outside the joint cavity.

Ligaments

Instability of the knee due to torn or relaxed ligaments is demonstrable in the lateral view. When the cruciate ligaments are involved, instead of the inverted V-shaped shadow with straight limbs, one or both limbs appear to sag. This is indicative of a relaxation of the respective cruciate. The anterior cruciate is involved most commonly. These findings serve to confirm the more reliable clinical signs. At the insertion of the anterior cruciate ligaments, there may be a small avulsion chip fracture of the anterior tibial eminentia.

The stability of the collateral ligaments is demonstrated in all the postero-anterior views as the respective joint spaces are spread. The amount of spreading is directly proportional to the ligamentous relaxation. Some cases reveal calcification in a torn collateral ligament, commonly

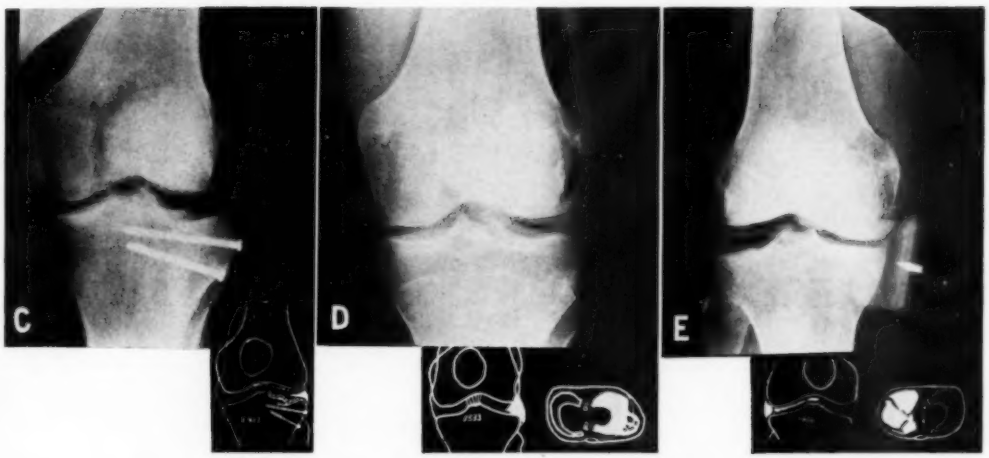

Fig. 10 C. Lateral tibial plateau fracture with essentially normal lateral meniscus. Note healed depression fracture with irregular articular surface; some blunting of the inner margin of the lateral meniscus.

L. S., 43 years. Left knee. Direct blow fracturing lateral tibial plateau, in 1945; open reduction and screw fixation. In 1947, screws removed and medial meniscus excised. Pain, weakness, aching. *Physical examination:* Lt. quad. −1″; no fluid; motion 180/115; anterior lateral tenderness; lateral instability ++. *Clinical diagnosis:* Fractured lateral meniscus. *Pneumoarthrographic diagnosis:* Tibial plateau fracture and tear of inner margin of lateral meniscus.

D. Cyst of lateral meniscus. Note the abnormal broad base of the lateral meniscus, with bulging of superior and inferior borders.

R. Z., 23 years. Right knee. Fox hole. Pain, swelling, stiffness. *Physical examination:* Rt. quad. −1 1/2″; fluctuant anterior lateral mass; no fluid; motion 180/45; no crepitus; lateral tenderness; stable joint. *Clinical and pneumoarthrographic diagnosis:* Cystic lateral meniscus. *Operative findings:* Cystic lateral meniscus.

E. Lateral fractured discoid meniscus. Note (1) irregular shadow of lateral meniscus extending across lateral joint space; (2) blunted shadow near base and thin irregular portion near tibial eminence; (3) widening of lateral joint space.

A. S., 38 years. Roller skating. Pain in lateral joint space, recurrent swelling, locking, instability. *Physical examination:* Rt. quad. −1/2″; no fluid; motion 180/45; crepitus; lateral joint tenderness; lateral instability +. *Clinical diagnosis:* Rupture of lateral meniscus. *Operative findings:* Fractured discoid meniscus, lateral.

referred to as Pelligrini-Stieda's disease (Fig. 14C).

Of diagnostic significance during the inflation of a joint is the reproduction of pain localized over a recently injured collateral ligament, whereas increasing intra-articular pressure does not produce meniscal pain.

Synovia

The capacity of the synovial space (80–120 c.c.) is best visualized in the lateral view. A decrease of this space or alteration of the normal contours of any portion of the joint is indicative of synovial or subsynovial pathological change.

The most common changes in chronic traumatic synovitis are associated with meniscal or any other intra-articular lesions which produce recurrent episodes of increased fluid in the joint. In such instances, the synovial outline of the suprapatellar pouch is thick and irregular. Synovial folds or plicae are increased in number and broadened (Fig. 13C). Pipkin and Virden (46) believe that thickened plicae may produce symptoms.

A localized form of thickened synovia in the anterior joint space is referred to clinically as a hypertrophied fat pad. In the lateral view, it is visualized as a large, lobulated, triangular, soft-tissue density which may almost obliterate the anterior joint space between the tibial and femoral condyles. Such a fat pad may overlap the anterior third of the medial meniscus and simulate a tear. Fibrosis or calcification is often seen in the fat pad (Fig. 3B).

Localized, round, dense soft-tissue masses, single or multiple, attached to the walls of the synovia, represent synovial tumors (Fig. 12D); differentiation of benign from malignant still is not possible.

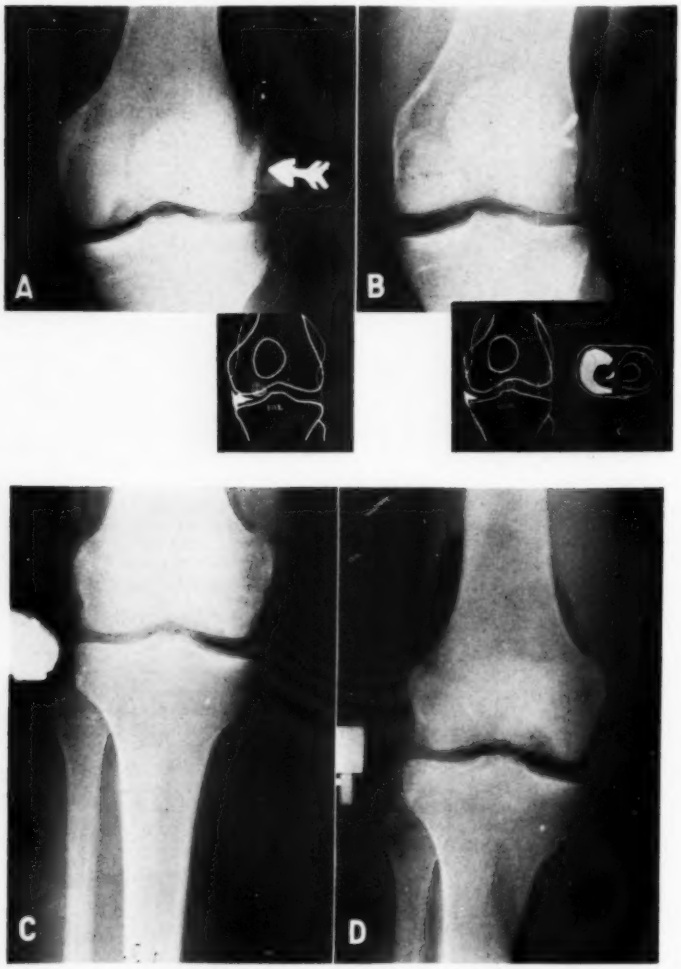

Fig. 11. Osteochondritis dissecans.

A. Osteochondritis dissecans of medial femoral condyle. Note (1) osteocartilaginous sequestrum projecting into joint space from medial femoral condyle; (2) normal medial meniscus (sequestrum barely visible on plain film).

B. Osteochondritis dissecans of medial femoral condyle. Note (1) defect in articular cartilage of medial femoral condyle; (2) loose osteochondromatous body partially detached; (3) normal medial meniscus. The plain films were reported normal. *Pneumoarthrographic diagnosis:* Osteochondritis dissecans; medial meniscus normal. *Operative findings:* Osteochondritis dissecans; partially detached cartilaginous body from medial femoral condyle, 2 × 1 cm.

C. Preoperative osteochondritis dissecans and fracture, medial meniscus. Note medial meniscal tear and irregular articular cartilage below sequestrum.

D. Same case as in C, six weeks after operation. Note (1) short, stubby remnant of surgically excised meniscus; (2) absence of sequestrum and filling in of defect; (3) smooth medial femoral articular surface.

Popliteal bursae (Fig. 12A) are seen as loculated, circular rarefactions, posterior to and communicating with the posterior joint pouches. There may be one or two. In the present series of 237 cases, popliteal bursae were present in 24 cases (10 per cent). A small percentage of these produced symptoms, in which event they are

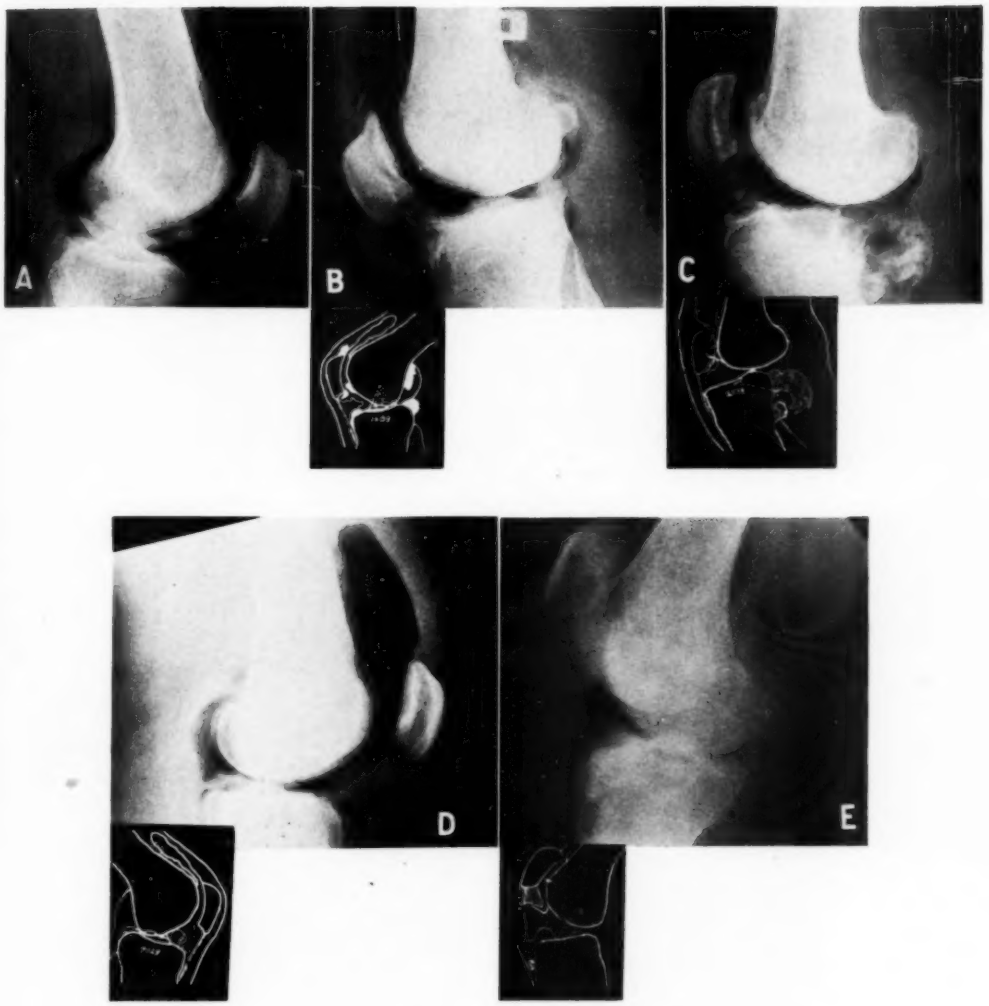

Fig. 12. The lateral pneumoarthrogram.

A. Normal lateral view, showing joint space, 90 c.c. capacity, with (1) suprapatellar pouch, (2) two posterior pouches, and (3) popliteal bursa (14 per cent). Note shadow of the cruciate ligaments and of the fat pad with its ligamentum mucosum.

B. Traumatic arthritis with osteochondrosis of patella, synovitis, and hypertrophy of fat pad. Note (1) extensive lipping of all joint surfaces; (2) marked osteochondrosis of patella; (3) irregular fat pad. *Pneumoarthrographic diagnosis:* Traumatic arthritis, severe; osteochondrosis of patella. *Operative findings:* Traumatic arthritis; fracture of medial meniscus.

C. Charcot knee (O_2 capacity, 250 c.c.) Note (1) irregular, slightly diminished synovial cavity; (2) marked lipping of patella and femur; (3) fragmentation of posterior tibia (shaded area); (4) anterior subluxation at tibia. *Pneumoarthrographic diagnosis:* Neurotrophic arthropathy (probably Charcot). *Operative findings:* Charcot knee.

D. Synoviomata. Note lobulated soft-tissue mass in fat pad region and small masses in suprapatellar bursa.

J. R., 27 years. Right knee. Contusion. Pain, recurrent swelling, clicking. *Physical examination:* Rt. quad. − 1″; fluid ++; motion 180/45; no crepitus; medial tenderness; instability (medial) +. *Clinical diagnosis:* Ruptured medial collateral ligament; chronic synovitis. *Pneumoarthrographic diagnosis:* Tumor of synovial origin. *Operative findings:* Synoviomata.

E. Ruptured patellar tendon. Note (1) superior displacement of patella; (2) soft-tissue mass below patella, consisting of fat pad and patellar tendon; (3) O_2 shadow extending under skin and subcutaneous tissue. *Operative findings:* Complete rupture of patellar tendon and bilateral rent of capsule. *Operative repair:* Patellar tendon sutered with fascia lata reinforced with wire. Capsular tear sutured bilaterally.

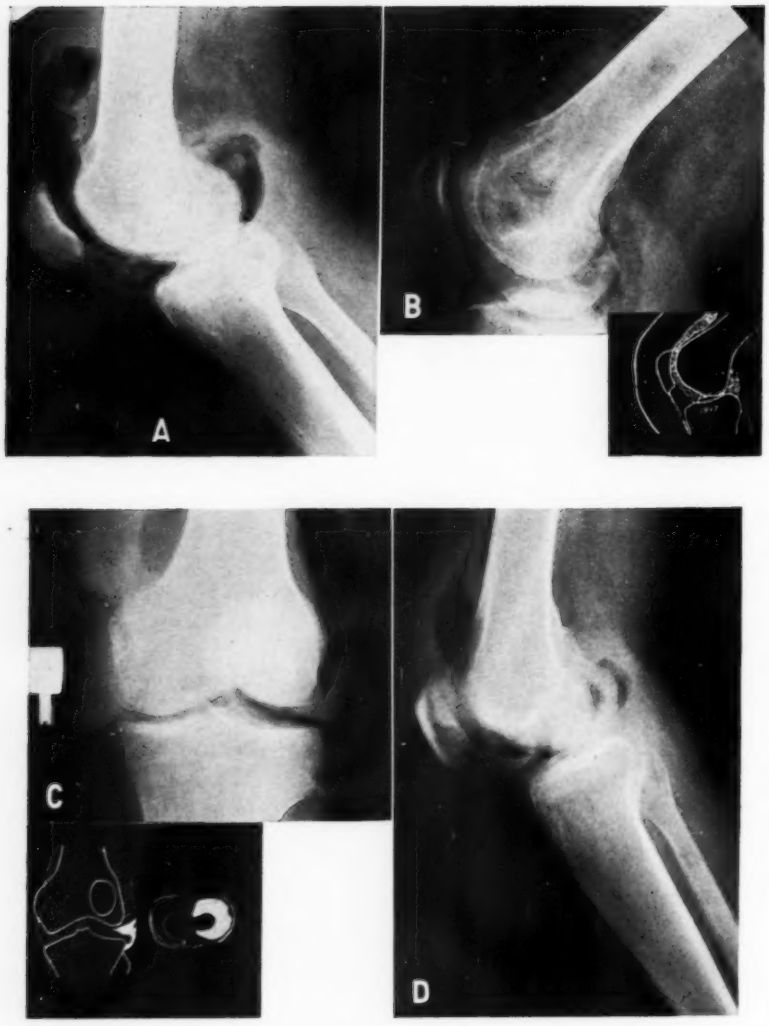

Figure 13.

A. Tuberculous synovitis. Irregular bursae with villous nodular infiltration. Note marked irregularity and difference in density of synovial pouches. *Pneumoarthrographic diagnosis:* Severe chronic synovitis, probably tuberculous. *Operative findings:* Tuberculous synovitis with articular destruction.

B. Tuberculous synovitis. Note (1) marked reduction in O_2 capacity, to 25 c.c.; (2) mottled appearance of synovial cavity, typical of rice bodies and granulation tissue; (3) marked soft-tissue swelling. *Pneumoarthrographic diagnosis:* Tuberculous synovitis. *Operative findings:* Tuberculous synovitis; no bone involvement.

C. Chronic villous synovitis. Anterior oblique view of lateral meniscus. Note (1) irregular soft-tissue densities in suprapatellar bursa and thickened synovial septa; (2) smooth tapering surfaces of lateral meniscus. *Pneumoarthrographic diagnosis:* Tumor arising from synovia (?); villous synovitis (?). *Operative findings:* Chronic villous synovitis; osteochondrosis of patella.

D. Infectious arthritis. Joint capacity reduced; bursa irregular, with marked soft-tissue density in patellar region. Note (1) reduction of O_2 capacity, with small suprapatellar pouch; (2) irregularity, thickening, and differences in density of synovia.

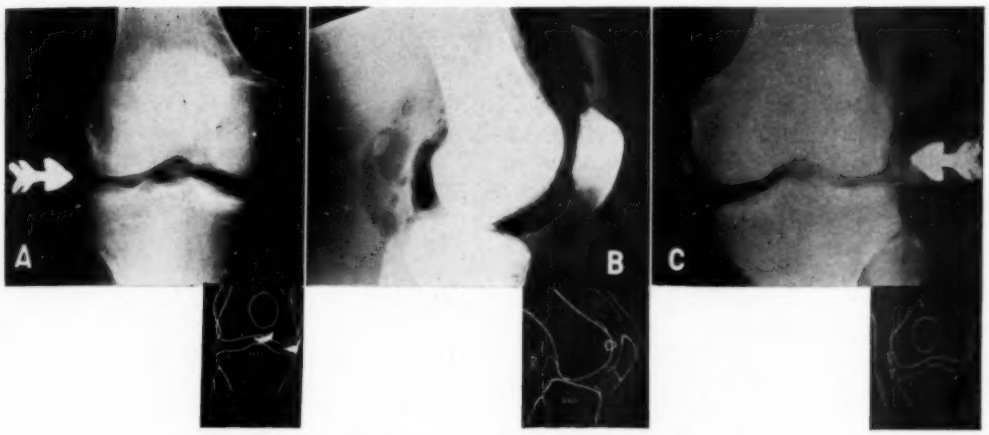

Fig. 14. Calcified and non-calcified loose bodies in the joint.

A. Note irregular loose body in anterior joint and normal medial meniscus. C. B., 26 years. Right knee. No definite trauma; on maneuvers. Two attacks of pain and swelling. *Physical examination:* Rt. quad. − 1/2″; fluid +; motion 180/35; subpatellar pain and tenderness ++; stable joint. *Clinical diagnosis:* Osteochondrosis of patella. *Pneumoarthrographic diagnosis:* Loose body in anterior joint; chondrosis of patella (lateral view). *Operative findings:* Loose body in anterior joint; osteochondrosis of patella; normal medial meniscus.

B. Note (1) two osteochondromatous bodies in joint space and one in popliteal bursa; (2) fibrotic fat pad. R. T., 21 years. Right knee. Onset during hike. Pain, swelling, stiffness, no locking. *Physical examination:* Rt. quad. − 1/2″; fluid ++; motion 180/35; crepitus +; slight diffuse tenderness; stable joint. *Clinical diagnosis:* Osteochondritis dissecans. *Pneumoarthrographic diagnosis:* Osteochondromatosis; fibrotic fat pad *Operative findings:* Three loose osteocartilaginous bodies; chronic synovitis; fibrotic fat pad.

C. Note (1) linear calcification in soft tissue of medial joint; (2) normal medial meniscus. J. B., 29 years. Left knee. Struck by machete. Pain, "snapping," instability, swelling. *Physical examination:* Lt. quad. −1/2″; fluid ++; motion 180/45; no crepitus; medial joint tenderness; instability (medial) ++. *Clinical diagnosis:* Fracture of medial meniscus; rupture of medial collateral ligament. *Pneumoarthrographic diagnosis:* Pellegrini-Stieda's disease; normal medial meniscus. *Operative findings:* Normal medial meniscus; calcification of medial collateral ligament.

commonly called "Baker's cyst." If surgery is indicated, the size of the bursa and location of the communicating channel is of practical importance. Inflation of the joint prior to surgery facilitates removal of the bursa.

Acute or subacute knee joint infections always result in a diminution of the joint space by 50 per cent or more (Fig. 13A, B, D). In acute suppurative arthritis (Fig. 13D), there is a marked diminution of the synovial cavity (40 c.c.). The synovial outline is indistinct and fuzzy. Plicae are not demonstrable, suggesting a destructive process.

In tuberculosis of the knee a varying picture is seen. In one type the joint space appears to be filled with granulation tissue, rice bodies, plus an absence of a definite synovial outline (Fig. 13B). In other types, the synovial cavity shows localized granulomas of varying sizes and stages (Fig. 13A). There is thickening without uniform destruction of the synovia which may be mistaken for a synovial tumor.

Cartilage and Bone

In addition to the arthritic bony changes which are readily seen in routine films, the pneumoarthrogram may reveal varying degrees of associated cartilaginous as well as synovial involvement. Any thinning, thickening, irregularity in contour, or break in the continuity of the articular surfaces of the femur, tibia, or patella indicates a pathological change.

In osteochondritis dissecans (Fig. 11) the articular cartilage overlying the sequestrum may be absent, or is thin or irregular and frayed. The loose or partially attached body composed of necrotic bone and degenerative cartilage is sharply outlined by oxygen. In the pneumoarthrogram the exact size of this body is delineated, whereas in routine films only the much smaller fragment is seen. Meniscal frac-

tures may be observed associated with osteochondritis dissecans.

Chondromalacia of the patella (Fig. 3B) is seen frequently as a thickening of its articular cartilage. The surface is irregular, wavy, and thickened, indicating an edematous, softened, and frayed cartilage. When the pathological process is more advanced, there are cupping and sclerosis of the patella, and the cartilage may show degenerative thinning (Fig. 12B). This is called osteochondrosis. This distinction is clarified by the pneumoarthrogram.

In infectious arthritis (Fig. 13D), in addition to the previously described synovial changes, the articular cartilage and menisci reveal varying degrees of destruction with thinning and fraying, dependent on the duration and severity of the infectious process. Subchondral bone, as expected, shows demineralization.

Fractures into the joint may produce varying degrees of cartilaginous irregularity (Fig. 10C). The pneumoarthrogram is an aid in determining the extent of involvement and the possible associated meniscal injury.

In a Charcot knee (Fig. 12C), the full extent of cartilage and bone disintegration is demonstrable. The synovial joint capacity may be markedly increased, to as much as 250 c.c.

Postoperative Changes

When indicated, pneumoarthrography is valuable even following surgery. Remnants and tears of a meniscus incompletely removed may be visualized, usually in the posterior third. Partial regeneration (fibrosis) of a completely excised meniscus, on the other hand, has been seen within six weeks (Fig. 11D).

Following the removal of large necrotic fragments of cartilage and bone in osteochondritis dissecans, the condylar and articular defects have eventually appeared rounded and smooth as they are partially replaced by fibrous tissue (Fig. 11D).

Statistical Evaluation

The present series of 237 cases (Table I) is divided into two groups. The first group of 163 cases covers the period from June 1946 to December 1947 before the present technic of pneumoarthrography was standardized. Oblique views were not taken routinely. In 107 of this group of 163 cases, operation was done. Pneumoarthrogram diagnoses were correct in 73.8 per cent, the clinical diagnoses in 69.2 per cent, and the combined clinical and roentgenologic diagnoses in 93 per cent. The percentage of error was 7 per cent in both the pneumoarthrogram and clinical diagnoses. Misinterpretation and poor films were contributing factors to the incorrect diagnoses.

Pneumoarthrography was done in a second group of 74 cases from December 1947 to August 1948. In 52 of these, operation was performed. In this group the improved roentgen technic, as described above, was used exclusively. Pneumoarthrogram diagnoses alone were

TABLE I. RESULTS OF PNEUMOARTHROGRAPHY OF THE KNEE IN 237 CASES

	Group I June 1946–Dec. 1947		Group II Dec. 1947–Aug. 1948		Total*
	Cases	Per Cent	Cases	Per Cent	Cases
Operated	107		52		474
Unoperated	56		22		545
Pneumoarthrogram	163		74		1019
Clinical diagnosis (checked by operative findings)					
(*a*) Correct	74	69.2	37	71.1	
(*b*) Partially correct	18	14.0	9	17.4	
(*c*) Incorrect	15	16.8	6	11.5	
Pneumoarthrographic diagnosis (checked by operative findings)					
(*a*) Correct	79	73.8	45	86.5	
(*b*) Partially correct	15	14.0	2	3.9	
(*c*) Incorrect	7	6.6	3	5.7	
(*d*) Technical errors	6	5.6	2	3.9	
Combined diagnoses					
(*a*) Clinical and pneumoarthrographic diagnoses both correct or partially correct	84		43		
(*b*) Clinical diagnosis only correct	8		3		
(*c*) Pneumoarthrographic diagnosis only correct	10		4		
(*d*) Neither diagnosis correct	5	4.7	2	3.9	
Combined diagnostic accuracy		95.3		96.1	

* Total of series includes series previously reported by Meschan and McGaw.

correct in 86.5 per cent, clinical diagnoses in 71.1 per cent; and the combined clinical and roentgen diagnoses in 96 per cent. The incidence of poor films was reduced to 2 cases (3.9 per cent), and in these the fault lay in interstitial air, which, obviously, should not be considered a result of poor roentgen technic. In addition the further increased knowledge of interpretation has helped to improve the number of correct diagnoses from 73.8 to 86.5 per cent.

DISCUSSION

During the past six years we have used pneumoarthrography with oxygen as the contrast medium routinely as a diagnostic aid in all problem cases of the knee. Over 1,000 cases have been observed and studied (by one of us, W. H. M.) with no evidence of embolus or any other serious complication. In two instances, the patients fainted while sitting in a wheel chair, due to apprehension and anxiety. Usually most of the oxygen is absorbed within twenty-four hours and the remainder in one or two days. In cases of recent increased fluid in the joint, six to seven days may be required for complete absorption. In ambulatory cases, the knee can be deflated through the same procaine wheal immediately after the films are obtained.

This procedure has eliminated the vague diagnosis of "internal derangement"; it has served to specify accurate preoperative diagnoses and establish definite pathological entities. Information can be obtained as to the type and exact location of a meniscal tear. Other pertinent changes can readily be diagnosed, such as cysts, discoid and hypermobile menisci, loose bodies, cruciate and collateral ligament ruptures or relaxations, synovitis, synovioma, osteochondritis dissecans, neuropathic and arthritic joints. In the majority of instances, these diagnoses cannot be made with routine films; or, if they are made, the complete pathological picture is not as clearly demonstrable as in the pneumoarthrograms. Experience has demonstrated that in many instances there may exist in a given knee more than one major abnormality which may be overlooked clinically.

By means of pneumoarthrography, the surgeon has been able to determine the type of surgery indicated, and also to avoid unnecessary surgery. The convalescent period is thereby shortened because of early accurate diagnosis.

In analyzing the results of pneumoarthrography, an attempt has been made to correlate those reported in previous series (McGaw and Weckesser, Meschan and McGaw), with those of the present study. As expected, with experience in interpretation and improvement in technic the percentage of accurate diagnoses has increased.

SUMMARY

1. A historical review of pneumoarthrography has been presented.

2. The physiological anatomy of the knee in relation to pneumoarthrography has been illustrated.

3. Oxygen as a contrast medium has been found to be ideal. The inflation technic has been described. No pulmonary emboli or any serious complications have been observed in over 1,000 cases examined by this method.

4. Improvements in roentgen technic have been developed as follows:

(*a*) Fluoroscopic localization of the joint for all six oblique views.

(*b*) All views for menisci postero-anterior.

5. Normal and pathological pneumoarthrograms have been illustrated and described in detail.

6. Roentgen diagnoses can now be made of the following conditions:

(*a*) Meniscal lesions: Fractures, dislocations, cysts, and congenital anomalies.

(*b*) Loose bodies: Calcified and noncalcified.

(*c*) Synovitis (traumatic or infectious), synovial tumors, fat pad hypertrophy and popliteal bursitis, etc.

(*d*) Articular and bony changes: acute and chronic arthritis, osteochondri-

tis dissecans, chondromalacia and osteochondrosis of the patella, Charcot joint, etc.

7. An evaluation has been made of 237 pneumoarthrograms, of which 159 were confirmed by surgery.

(*a*) Technical errors have been reduced from 5.6 to 3.9 per cent;

(*b*) Incorrect diagnoses have been reduced from 6.6 to 5.7 per cent.

(*c*) Diagnoses only partially correct have been reduced from 14 to 3.9 per cent.

(*d*) Diagnostic accuracy has improved from 73.8 to 86.5 per cent.

(*e*) The combined clinical and pneumoarthrographic diagnoses were correct in over 95 per cent.

As the use of pneumoarthrography has become routine, the scope of its usefulness has increased. It permits early, accurate, and complete diagnosis and renders invaluable preoperative and operative aid to the surgeon. Its observed safety in over 1,000 cases recommends it for routine use.

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SUMARIO

Estudios del Alcance de la Neumoartrografía de la Rodilla como Auxiliar Diagnóstico

La neumoartrografía con oxígeno como medio de contraste ha sido utilizada sistemáticamente por los AA. durante los últimos seis años en todos los problemas clínicos que afectan la rodilla, sin observar embolias pulmonares u otras complicaciones graves en más de 1,000 casos.

Al describir la técnica de la inflación con oxígeno y del examen roentgenológico, señálase que para conseguir los mejores resultados, hay que: dilatar los espacios articulares con un sencillo dispositivo mecánico; obtener siete vistas corrientes, todas en la proyección posterior-anterior; y emplear factores técnicos que faciliten un máximum de pormenores sobre los tejidos blandos y los huesos. Las vistas comprenderán: 3 con la dilatación articular medial, 3 con la dilatación articular lateral y 1 lateral sin dilatación.

Con este método cabe hacer el diagnóstico roentgenológico de los siguientes estados: (a) fracturas, dislocaciones, quistes y anomalías congénitas de los meniscos;

(b) cuerpos flotantes calcificados y sin calcificar; (c) sinovitis traumática e infecciosa, tumores sinoviales, hipertrofia adiposa y bursitis poplítea; (d) alteraciones articulares y óseas, tales como artritis aguda y crónica, osteocondritis disecante, condromalacia y osteocondrosis patelar, articulación de Charcot, etc.

Analízase una serie de 237 casos estudiados con la neumoartrografía, en 159 de los cuales la operación confirmó el diagnóstico: 163 fueron examinados desde junio, 1946 hasta diciembre, 1947, y 74 desde diciembre, 1947. Con la técnica perfeccionada descrita, los errores técnicos han descendido a 3.9 por ciento y la exactitud diagnóstica ha subido de 73.8 a 86.5 por ciento. Los diagnósticos clínico y neumográfico combinados fueron acertados en más de 95 por ciento de toda la serie.

Recomiéndase la neumoartrografía de la rodilla como procedimiento que permite hacer el diagnóstico temprano, exacto y completo y que presta insuperable ayuda preoperatoria y operatoria al cirujano. Su inocuidad confirmada constituye otra recomendación más.

DISCUSSION

I. Meschan, M.D. (Little Rock, Ark.): It was indeed gratifying to see Dr. Sachs' beautiful illustrations and to read his further corroboration of the historical review, the anatomical discussion, and the statistical survey which I reported a year ago, covering a four-year investigation period and some 800 cases. Dr. Sachs has shown the application of pneumoarthrography of the knee to several inflammatory and degenerative pathologic entities which I had not previously described.

The main technical improvement in the procedure between 1904 and 1938 was the spreading of the knee joint space, which permits a more accurate demonstration of the internal structures of the knee.

This, I believe, is the fundamental principle behind present day pneumoarthrography of the knee, no matter how it is accomplished, and it is responsible for elevating this procedure from its previous obscurity to its present success. Although this was accomplished by Nordheim in 1938, in our own institution it was introduced by Drs. McGaw and Weckesser. Experience had already disproved any delusions about possible inherent danger in the procedure, and progress could be readily made thereafter.

As with most other radiographic procedures, the interpretation of the films requires extensive experience and the best of radiographic technic. Once that experience is acquired, the procedure can be very valuable. Combining our roentgen observations with the clinical information (which, at best, is only about two-thirds accurate), we showed an accuracy of 93 per cent in our previous series, and now Dr. Sachs has reported a 95 per cent accuracy in a smaller, independent series of cases.

There are minor differences in our technic and that which Dr. Sachs has described. As for our present technic, the knee is fluoroscoped and placed in a position to show the internal structures to the best advantage under fluoroscopic control, with spreading of the knee joint. We usually employ a straight anteroposterior, or a postero-anterior, or a slight oblique projection, or all three. I have not found the marked oblique projection very useful, but each case is adjudged separately. Nor have I been bold enough to discard the anteroposterior projection. I have at least three cases in which this view was the only one to demonstrate the pathology clearly, and one of these appears in my article published one year ago. Moreover, this view, as compared with the postero-anterior projection, shows the presence of fluid, which, in itself, is sometimes valuable information, undetected by physical means. Merely because one projection is more valuable than another is not an indication for discarding completely the less valuable of the two.

In conclusion, I should like to reiterate the belief that to promote the greatest accuracy, observations with this procedure, as with other radiographic procedures, should be correlated with all the clinical information at our disposal. In and by itself, it is more accurate than the clinical examination or routine radiographic examination alone, but our over-all accuracy is enhanced when we utilize the clinical data as well. Pneumoarthrography deserves a definite place in our diagnostic armamentarium. It provides guidance and confidence in the clinical approach to the knee joint, especially in traumatic pathology. No greater claim can be made for any diagnostic procedure.

Massive Calcification in Infarcted Myocardium[1]

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CALCIFICATION in myocardial infarcts is relatively uncommon, and only occasionally does the radiologist make the diagnosis during life. Although there are not more than twenty undoubted cases in the medical literature, the condition is not excessively rare. It occurs in a well defined group of patients with a characteristic clinical picture and is readily demonstrated by standard radiological technics.

In a patient who has a calcified infarct, the diagnosis is clinically valuable in giving an unequivocal demonstration of the state of the myocardium, and in indicating the etiology of cardiac enlargement, which is usually present. The diagnosis is of some prognostic importance, since these patients, like others with coronary artery disease, are prone to sudden death. The diagnosis is of therapeutic significance in so far as the calcification may be mistaken for calcific pericarditis; calcified infarcts are not—at present—amenable to cardiac surgery.

The more common cardiac calcifications—in valve rings, valve leaflets, coronary arteries, and pericardium—are now well known and readily recognized. Technics for their detection and identification have been established (19). The pathologic and clinical significance of each is well defined. It is the purpose of this paper to describe the pathologic background of calcified myocardial infarcts, their appearance, characteristic location, and contours, and to describe the patients in whom they occur.

MATERIAL

The study is based on 14 patients[2] with calcified myocardial infarcts. Nine of the 14 infarcts have been confirmed by autopsy. Calcification was visible in films made during life in 8 patients: in 3 of the 9 autopsied cases, and in 5 others. Eight of the 9 postmortem examinations included special films of the heart. Seven of the hearts were examined by opaque injection and dissection of the coronary arteries. A series of 63 consecutive old myocardial infarcts without calcification, examined postmortem, was also studied for control purposes.

LITERATURE

The first description of gross calcification in a myocardial infarct was published in 1908 by Simmonds (18), the lesion being unexpectedly discovered at autopsy. No additional proved case was reported until 1924, when Scholz (15) published a detailed account of a case demonstrated by x-ray films during the life of the patient, with autopsy verification and postmortem roentgen study.

Subsequently, several additional reports have appeared (1–10, 12, 13). Parkinson's (11) study of cardiac aneurysms includes a proved case with massive calcification in the aneurysmal wall, and a second case, unproved but convincing. Schwedel and Gross's (17) study of cardiac aneurysms mentions a proved case, as does the chapter on cardiac aneurysms in Schwedel's book (16).

[1] This study was supported in part by the Life Insurance Medical Research Fund. Presented at the Thirty-fourth Annual Meeting of the Radiological Society of North America, San Francisco, Calif., Dec. 5–10, 1948.

[2] Cases 1 and 8, New England Deaconess Hospital, Boston, Mass.; Cases 2–7, Beth Israel Hospital, Boston, Mass.; Cases 9–11, Peter Bent Brigham Hospital, Boston, Mass.; Case 12, Veterans Administration Hospital, Palo Alto, Calif.; Case 13, San Francisco County Hospital, Stanford Service (included through courtesy of Dr. L. H. Garland); Case 14, San Francisco County Hospital, University of California Service (included through courtesy of Dr. A. J. Williams).

Several of the calcified infarcts have been demonstrated during life (2, 3, 5, 7, 9–12, 15), and a number of postmortem films have been published (1, 2, 5, 8, 11, 15, 16). In one case, the coronary vessels were studied by an injection method (4).

INCIDENCE

Six cases were found in the decade 1937 through 1946 in a 200-bed general hospital. At another 200-bed hospital, 3 cases were seen within thirteen years. In a consecutive series of 813 unselected postmortem heart radiographs, there were 5 showing calcified infarcts, an incidence of 0.6 per cent. The same series included 68 old myocardial infarcts, of which 7.6 per cent were massively calcified. Calcification occurred only in large infarcts. Twenty-nine of the old infarcts measured at least 6 × 6 cm., 5 × 7 cm., or larger, including all 5 with calcification. The incidence of calcification in these large old infarcts was 17.2 per cent.

CLINICAL FEATURES

All of our 14 patients, and all reported in the literature, were males. In our control series of 63 old infarcts *without* calcification, 22 per cent were in women. The lack of female patients in our series of 14, however, does not rule out the possibility of calcified infarcts in females, as the first 14 consecutive old infarcts *without* calcification also happened to be in males; a chance run of 14 males is therefore possible. Moreover, we have recently seen what is probably a calcified myocardial infarct in a sixty-four-year-old woman who had a history of a classical acute infarction ten years before.[3]

The average age of the patients was sixty-three years, but one of our patients was only forty-four, and one in the literature was only thirty. Our oldest patient was seventy-four. The average age in the previously reported cases of calcified infarcts was sixty-two years. The average age in our 63 old myocardial infarcts *without* calcification was 63.8 years.

Many of the men were able to do heavy manual work in spite of the myocardial lesion. Three of our patients (Cases 1, 2, 6), were professional packers or balers, and one was a laborer (Case 14). Cases have previously been reported in laborers (8), "strenuous workers" (5, 15), truckmen (6, 13), and a blacksmith (10). Two of our patients were physicians (Cases 8, 10).

Nine patients had angina pectoris. In 6 angina was severe, and each of the 6 had a history of acute myocardial infarction which had occurred from six to nineteen years before (Cases 5, 6, 8, 11, 12, 13). Three patients had mild angina, with no obtainable history of an acute myocardial infarction (Cases 4, 7, 9).

Three patients, including the 2 with the largest infarcts in the group, were apparently free of cardiac symptoms until just before death (Cases 1, 2, 3). The two with the largest infarcts did heavy manual work until their terminal illness.

On physical examination, 8 of 13 patients showed cardiac enlargement (Cases 1, 6, 8, 9, 11, 12, 13, 14), and 8 of 14 had heart sounds described as "distant" or of "poor quality" (Cases 1, 4, 6, 8, 10, 12, 13, 14). Only one patient had a systolic murmur and he had a very large heart (Case 8). No diastolic murmurs were heard.

None of the patients had hypertension when seen, but hypertension is known to have occurred in 2 (Cases 4, 6) before the onset of angina pectoris or acute infarction. In 2 of the cases in the literature (1, 2) there was mild hypertension.

Eleven of the 14 patients had electrocardiograms (Cases 1, 2, 5, 6, 7, 8, 9, 11, 12, 13, 14). Each showed evidence of myocardial damage, and 8 of the 11 showed disturbance of rhythm or conduction. Three had auricular fibrillation (Cases 1, 6, 11), 2 had paroxysmal ventricular tachycardia (Cases 2, 12), and 6 had intraventricular block or bundle-branch block (Cases 6, 8, 9, 11, 12, 14). Two pa-

[3] This case is reported through the courtesy of Dr. Ann Purdy of San Francisco.

TABLE I: MASSIVE CALCIFICATION IN MYOCARDIAL INFARCTS: CLINICAL OBSERVATIONS

Case No. and Hospital*	Age and Occupation (All males)	Angina Pectoris†	Clinical Infarction	Blood Pressure	Known Previous Hypertension	Congestive Heart Failure	Sudden Death	Calcification Visible Roentgenographically Antemortem	Autopsy
1 (ND)	61. Baler	0	0	110/70	0	0	+ (pulmonary embolus)	+	+
2 (BI)	44. Packer	0	0	"Shock"	0	0	+ (paroxysmal tachycardia)	+	+
3 (BI)	67. Druggist	0	0	148/72	0	0	+ (acute pulmonary edema)	No x-ray	+
4 (BI)	74. ?	+	0	110/65	+	0	0	No x-ray	+
5 (BI)	54. Druggist	++	+: *8* yr. before	150/90	0	0	+ (mechanism unknown)	No x-ray	+
6 (BI)	71. Packer	++	+: *6* yr. before	?	+	0	+ (coronary occlusion)	0	+
7 (BI)	64. Florist	+	0	150/80	0	0	+ (myocardial infarction)	+	+
8 (ND)	54. Physician	++	+: *10* yr. before	118/80	0	+	0	0	+
9 (PB)	62. Painter	+	0	140/90	0	+	0	+	0
10 (PB)	74. Physician	?	?	"Shock"	?	0	+ (mesenteric occlusion)	No x-ray	+
11 (PB)	71. Salesman	++	+: *14* yr. before	135/80	0	+	Living	+	
12 (VP)	62. Barber	++	+: *19* and *7* yr. before	150/95	0	0	Living	+	
13 (SC)	58. Accountant	++	+: *7* yr. before	90/75	0	0	Living	+	
14 (SC)	66. Mechanic	0	0	90/50	0	+	Living	+	

* ND: New England Deaconess Hospital, Boston, Mass. BI: Beth Israel Hospital, Boston, Mass. PB: Peter Bent Brigham Hospital, Boston, Mass. VP: Veterans Administration Hospital, Palo Alto, Calif. SC: San Francisco County Hospital, San Francisco, Calif.

† + mild angina pectoris. ++ moderate or severe angina pectoris.

tients (Cases 7, 8) had significant ST displacement, and one of these (Case 7) proved at autopsy to have a fresh myocardial infarct.

Only 4 of our patients had congestive heart failure (Cases 8, 9, 11, 14), but 8 of the 16 patients in the literature in whom the point is mentioned had failure (2, 3, 8, 10, 11, 13, 15, 16). Seven of our 10 patients who are now dead had a sudden death. The causes of abrupt exitus included fresh coronary occlusion (Case 6), fresh myocardial infarction (Case 7), pulmonary embolus (Case 1), mesenteric occlusion (Case 10), acute pulmonary edema (Case 3), and paroxysmal ventricular tachycardia (Case 2). One patient (Case 5) died at home, without demonstrable cause postmortem for the sudden end.

Two patients died in congestive failure (Cases 8, 9), and 1 died of urinary sepsis (Case 4). Four patients (Cases 11, 12, 13, 14) are now living.

Clinical features of the 14 patients are tabulated in Table I.

PATHOLOGY

Nine of the 10 patients who died were examined postmortem. All the hearts were enlarged, averaging 513 gm. The smallest was 370 gm.; the largest, 700 gm. Six of the infarcts lay in the anterior wall of the left ventricle near the apex (Cases 1, 2, 4, 5, 6, 8), 2 were high posteriorly in the left ventricle near the base (Cases 3, 7), and 1 was in the interventricular septum (Case 10).

All of the infarcts were large, ranging from 6 × 6 cm. or 5 × 7 cm. to involvement of almost the entire left ventricular wall. Each calcified mass was smaller than the old infarct in which it was contained. The smallest calcification measured 2 × 2 cm., in an infarct measuring 6 × 6 cm. The largest calcification measured 7 × 9 cm., in an old infarct occupying almost all of the anterior and lateral wall of the left ventricle.

Each calcified mass lay embedded in fibrous tissue, into which it merged peripherally. The mass was rigid, board-

TABLE II: MASSIVE CALCIFICATION IN MYOCARDIAL INFARCTS: PATHOLOGICAL FINDINGS

Case No.	Heart Weight (gm.)	Adherent Pericardium	Postmortem Film	Infarct Site	Infarct Size (cm.)	Calcification Size (cm.)	Mural Thrombi	Opaque Coronary Injection	Dissectable Anastomosis	—Old Occlusion or Marked Narrowing— Left Descending	Left Circumflex	Right Coronary
1	500	+	+	Anterior	Entire ant. wall	9 × 7	0	+	+	+	0	0
2	460	+	+	Anterior	Entire ant. wall	7 × 7	0	+	0	+	0	0
3	485	0	+	Posterior	9 × 5	5 × 2.5	0	+	0	+	+	0
4	625	+	+	Anterior	7 × 5	5 × 3 and 3 × 2	+	+	0	+	+	+
5	585	0	+	Anterior	Entire ant. wall	3 × 2	0	+	0	+	0	0
6	370	0	+	Anterior	6 × 6	2 × 2	0	+	0	+	0	+
7	435	0	+	Posterior	7 × 5	4.5 × 4.5	0	+	+	+	+	+
8	700	0	0	Anterior	6 × 6	5 × 5	+	0		+	0	0
10	460	0	+	Interventricular septum	Entire septum	Entire septum	0	0		+	+	+

like, and resistant to fracture. In 3, the pericardial sac was adherent over part of the infarct. The endocardial surface was a dull opaque yellow, calcified in lamellated segments. An organized mural thrombus was seen on the endocardial surface in 2 hearts.

Thinning of the ventricular wall occurred in each of the old infarcts examined pathologically, with hollowing out of the endocardial surface. Each, therefore, represented a calcified "ventricular aneurysm." However, in only 5 of the hearts was there an external bulge discrete enough to suggest that it might have been recognized as an aneurysm by contour, radiologically, during life (Cases 2, 4, 5, 6, 7).

In 7 of the hearts, the arrangement of the coronary arteries was studied by Schlesinger's (14) method of injection and dissection. In 6 (Cases 1–6) the coronary tree showed an anatomical distribution pattern of right coronary preponderance; that is, a large right coronary relative to the size and distribution of the left coronary. This pattern occurs in 48 per cent of human hearts. It is known to be a pattern favorable for survival after myocardial infarction, and therefore favorable for the development of a healed infarct (14*a*). The seventh heart (Case 7) had a balanced circulation pattern, a distribution also known to be favorable for the development of a healed infarct. None showed the left coronary preponderance pattern known to be unfavorable for survival after left ventricular infarction.

The coronary vessels of each heart, as examined by injection and dissection, showed at least one old occlusion, and often showed multiple occlusions. In 2, there were old occlusions or old very marked narrowings of each of the three main coronary vessels (Cases 4, 7). The two hearts with the largest infarcts and the largest calcifications (Cases 1, 2) each showed only a single site of marked narrowing in the left anterior descending coronary vessel.

Pathological features of the autopsied cases are tabulated in Table II.

RADIOLOGIC FEATURES

Ten of the patients had films made during life (Cases 1, 2, 6, 7, 8, 9, 11, 12, 13, 14). Each showed cardiac enlargement, and each showed enlargement of the left ventricle. In 2, the contour exhibited a discrete rounded protrusion readily classified as a ventricular aneurysm (Cases 9, 13). In 1 (Case 13), the aneurysmal bulge lay at the edge of a calcified mass and con-

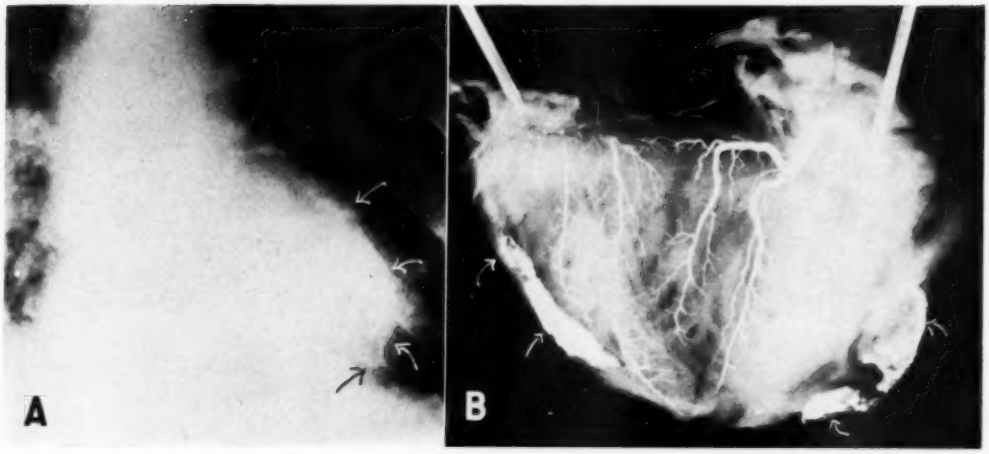

Fig. 1. Massive calcification in left ventricular wall. Case 1: 61-year-old baler, without angina pectoris or history of heart attack. Death from pulmonary embolism. A. Radiographic demonstration during life. B. Postmortem roentgenogram of unrolled heart after opaque coronary injection. Massive plaque of calcification (bisected and separated by opening cut) in left ventricular wall.

sisted of a soft-tissue protrusion with only a small fragment of protruding calcification at its base. In the other (Case 9) the calcification itself formed a localized hemispherical cell. In 5 others, the entire left ventricle bulged diffusely, but it would be difficult to classify these as ventricular aneurysms by contour alone (Cases 1, 7, 11, 12, 14).

Myocardial calcification was demonstrated in 8 of 10 patients who had films made during life (Cases 1, 2, 7, 9, 11, 12, 13, 14). The smallest visible calcification was a 1 × 1 cm. area in an underpenetrated film; it was part of a much larger calcification as seen postmortem (Case 2). The largest visible calcification measured 4 × 8 cm. in greatest diameters (Case 14).

Six calcifications involved the cardiac apex. One involved the apex but its visible portion was in the upper part of the left ventricular wall laterally. One was in the midportion of the left ventricle posteriorly and laterally.

The smaller calcifications were hemispherical. The larger calcifications appeared as dense plaques conforming to the shape of the left ventricular wall in which they lay. The external border of the calcification was smooth and continuous in 4, slightly scalloped in 2, and an interrupted curve in 2 others. The inner portion of the calcification varied from dense and continuous to jagged and lamellated; in some, it faded off into the depths of the ventricular density.

Each of the calcifications showed a soft-tissue rim of 2 mm. or more externally in all projections, thus helping to differentiate it from pericardial calcification, which should involve the extreme periphery of the heart shadow in at least one projection. The myocardial location of the mass and its size and shape allow it to be readily distinguished from the C-shaped calcification of the mitral annulus fibrosus or the nodular calcification of mitral or aortic leaflets.

Seven of our patients were studied fluoroscopically (Cases 7, 8, 9, 11, 12, 13, 14). Two showed decrease or absence of pulsation in the involved area (Cases 12, 13). Paradoxical pulsation was seen at the edge of one infarct (Case 12). The calcification has been seen to move with the heart beat, but the brisk dancing movement characteristic of calcified valves has not been observed.

Two of the 10 films made during life failed to show myocardial calcification. One of these was an underpenetrated bedside film (Case 6). The other was a film

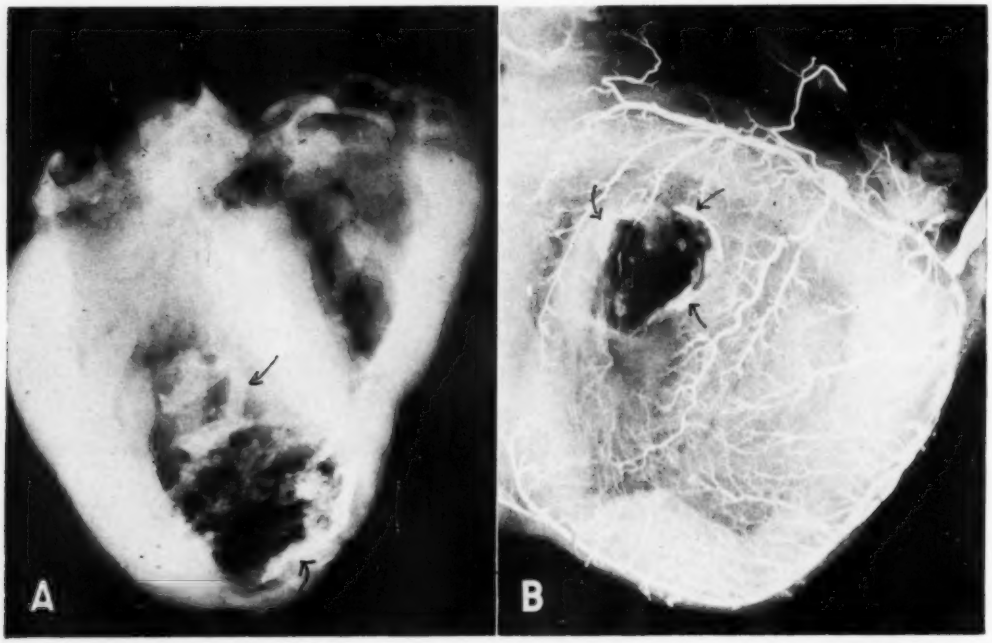

Fig. 2. Calcification in left ventricular wall thinned by old infarction. A. Case 2: 44-year-old packer, without previous recognized cardiac disorder; sudden death in paroxysmal ventricular tachycardia. Calcification visible in roentgenogram during life. Postmortem roentgenogram. B. Case 7: 64-year-old florist with angina pectoris, and sudden death from fresh myocardial infarction. Postmortem roentgenogram after opaque coronary injection.

of a patient with a very large heart (700 gm. at autopsy) (Case 8).

Six of the 8 visible calcifications were seen and described during the patient's life (Case 1, 9, 11, 12, 13, 14), but 2 were identified only on re-examination of the films after autopsy (Cases 2, 7). Of the 6 seen during life, 5 were identified as calcified infarcts, while the other (Case 1) was interpreted as pericardial calcification.

ILLUSTRATIVE CASES

CASE 1: A. B., a baler, aged 61, entered the hospital on Oct. 10, 1945, for surgical exploration of a known intrapulmonary mass. He had not had dyspnea, orthopnea, angina pectoris, or peripheral edema, nor any episode recognizable as a myocardial infarction. Physical examination showed, in addition to the physical signs of consolidation in the right lower lobe, slight cardiac enlargement, diminished heart sounds, and a slightly irregular pulse of 78 per minute. No murmurs were heard. Blood pressure was 110/70. Laboratory findings were not remarkable. A blood Hinton test was negative.

A film of the chest showed a partially excavated mass in the right lung base medially. The heart was enlarged, with sharpness of the left cardiac border suggesting pleuropericardial adhesion. An irregular, jagged-edged calcific plaque, 7.5 × 1.8 cm. in greatest diameters, was seen in the apex of the left ventricle, just inside the cardiac silhouette.

At exploratory thoracotomy on the seventh hospital day, the mass was found to be an epidermoid carcinoma, inoperable because of mediastinal extension. On the second postoperative day, auricular fibrillation was discovered, and the right leg became pulseless and later gangrenous. During supracondylar amputation of the gangrenous leg three days later, the patient suddenly expired.

At autopsy, the heart was found to be enlarged, weighing 500 gm., and the parietal pericardium was adherent to a portion of the left ventricular wall 4 cm. in diameter. A long, branched antemortem pulmonary embolus, apparently dislodged from the right femoral vein, which it duplicated in contour and branching, lay in the pulmonary artery with its tail coiled in the right ventricle and right atrium. The anterior wall of the left ventricle consisted of a dense, firmly calcified plaque measuring 9.0 × 7.0 × 0.3 cm. The wall was thinned but rigid, and no external bulge was evident. The endocardial surface of the calcified mass was composed of an agglomeration of yellow-white calcific lamellae with irregularly scalloped crevices between the segments.

Microscopic examination of the lesion showed the endocardium and inner three-fourths of the myocardium replaced by dense collagenous tissue heavily infiltrated with calcification and spicules of bone.

Opaque injection and dissection of the coronary arteries showed the right coronary artery preponderant. An atheromatous plaque near the origin of the left anterior descending branch produced extreme narrowing of the lumen; beyond this point the left descending vessel was filled by injection mass from the right coronary artery, the mass reaching the left branch by means of a dissectable anastomosis from the right coronary artery. The remainder of the coronary tree showed only a few atheromatous plaques with slight narrowing of the lumen.

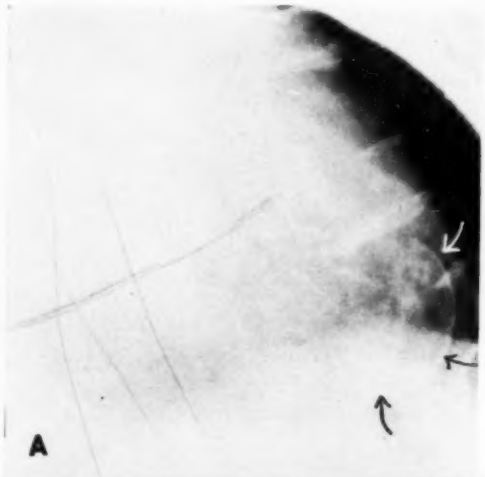

Fig. 3. Calcified ventricular aneurysm. A. Case 9: 62-year-old painter with angina pectoris. Fatal congestive heart failure. No autopsy. B. Case 13: 58-year-old accountant with severe angina pectoris and history of myocardial infarction seven years earlier. Living.

Fig. 4. Calcification in left ventricular wall. Case 11: 71-year-old salesman with severe angina pectoris, congestive heart failure, and history of myocardial infarction fourteen years earlier.

CASE 2:[4] J. O., a glass packer, age 44, entered the emergency ward on Nov. 5, 1937, in collapse, following the abrupt onset of palpitation and precordial pain. Previous chest pain, angina pectoris, palpitation, and dyspnea were denied. There was no known episode in the past suggesting a myocardial infarction. Physical examination showed the heart enlarged to the left. Heart sounds were not remarkable. A few basal râles were heard. The pulse was very rapid, 180 per minute, and regular. An electrocardiogram showed paroxysmal ventricular tachycardia. A bedside film of the chest showed the heart enlarged, with a rounded bulge of the left ventricle and a faint 1 × 1 cm. calcific density inside the left ventricular silhouette.

The patient was treated with oxygen, morphine, and quinidine, but expired four hours after admission.

At autopsy, the heart was found to be enlarged,

[4] This patient was previously reported as Case 19 in a paper by BLUMGART, H. L., SCHLESINGER, M. J., AND DAVIS, D.: Studies on the Relation of the Clinical Manifestations of Angina Pectoris, Coronary Thrombosis, and Myocardial Infarction to the Pathologic Findings. Am. Heart J. **19:** 1–91, January 1940.

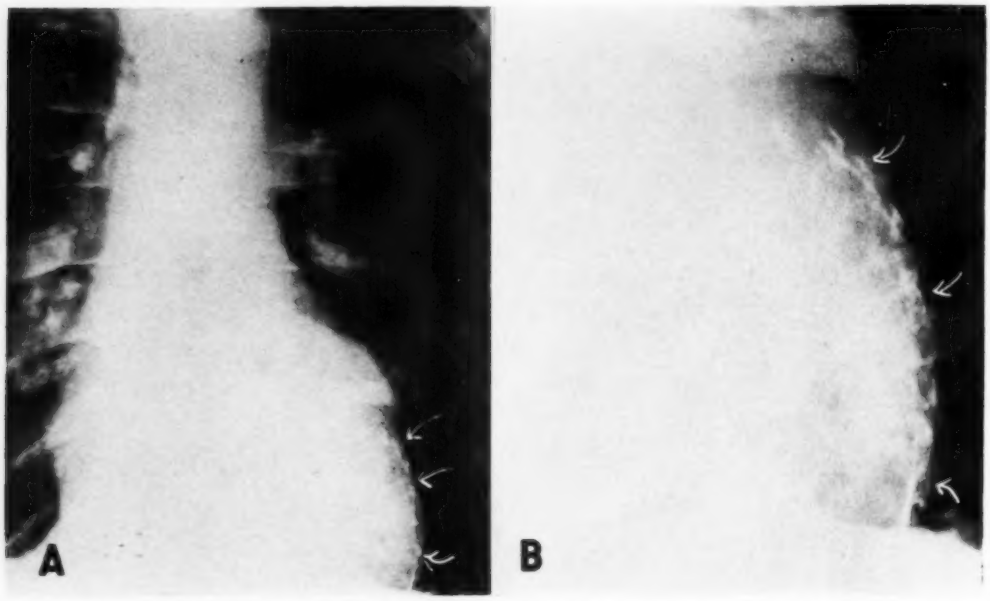

Fig. 5. Massive calcification in left ventricular wall. Case 14: 66-year-old mechanic with congestive heart failure, without angina pectoris or history of myocardial infarction. A. Heavy calcification in left ventricular wall. B. Detail view of ventricular myocardial calcification. Postero-anterior roentgenograms during life.

weighing 460 gm. Firm adhesions bound the pericardium to the mediastinal pleura on the left, and similar adhesions existed between the parietal pericardium and part of the left ventricular wall anteriorly. Beneath the adherent area lay a slightly bulging dense calcific mass, measuring 7.0 × 7.0 × 0.3 cm. Microscopic examination of the cardiac lesion showed dense fibrous tissue and a scattering of degenerated muscle fibers.

Opaque injection and dissection of the coronary arteries showed the right coronary artery preponderant. There was an old calcific occlusion of the left descending coronary artery 2 cm. below its origin; the lumen distal to the occlusion was patent and filled by injection mass from anastomotic vessels of the left coronary system. The remainder of the coronary tree showed only a few small atheromatous plaques with only slight narrowing of the lumen.

SUMMARY AND CONCLUSIONS

1. Massive calcification may appear in the fibrosed myocardium of patients who survive large myocardial infarctions for six years or more.

2. Hearts showing massive myocardial calcification are apt to be those congenitally provided with coronary artery distribution patterns favoring survival after infarction.

3. Massive myocardial calcification is seen most commonly in aged or aging men with enlarged hearts without hypertension or murmurs. Most have angina pectoris, and many have an old history of acute myocardial infarction.

4. Patients with calcified myocardial infarcts, like others with coronary artery disease, are liable to sudden death or to death in congestive heart failure.

5. Calcification in myocardial infarcts usually involves the cardiac apex. It may be differentiated from pericardial calcification by its position in, rather than on, the ventricular wall.

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SUMARIO

Calcificación Masiva en el Infarto Miocardíaco

Este estudio de infartos miocardíacos calcificados comprende 14 casos, 9 de ellos estudiados en la autopsia. A base de esta serie, descríbese la anatomía patológica, así como el aspecto, localización típica y contornos de los infartos, junto con la clase de enfermos en quienes se presentan los mismos.

Puede presentarse calcificación masiva en el miocardio fibrosado de los enfermos que sobreviven grandes infartos miocardíacos por seis años o más.

Los corazones que revelan calcificación miocardíaca masiva suelen ser los provistos congénitamente de patrones de distribución de las arterias coronarias que favorecen la sobrevivencia después del infarto.

La calcificación miocardíaca masiva es observada más habitualmente en las personas ancianas o próximas a la ancianidad con hipertrofia cardíaca, pero sin hipertensión o soplos. La mayor parte padecen de angina de pecho y muchos tienen antecedentes de infarto miocardíaco agudo.

Los enfermos con infartos miocardíacos calcificados, así como otros que padecen de afección de las coronarias, corren el peligro de una muerte súbita o de morir de una insuficiencia cardíaca congestiva.

La calcificación en los infartos miocardíacos suele afectar la punta del corazón, pudiendo diferenciarse de la calcificación pericardíaca por radicar en, más bien que sobre, la pared ventricular.

DISCUSSION

Arthur Selzer, M.D. (San Francisco, Calif.): The recognition of an old myocardial infarct is based in most cases on a typical history of coronary occlusion and on residual changes in the electrocardiogram. In addition, the roentgenologist may assist the clinician in such a diagnosis by demonstrating a cardiac aneurysm, an area of absent pulsation or a paradoxical pulsation of a portion of the cardiac shadow. Dr. Brean and his co-workers have shown another important roentgen-ray sign proving conclusively the existence of an old massive infarction. From the cardiologist's standpoint, myocardial calcifications proving the presence of an old infarct may be an important aid in making such a diagnosis in cases where other diagnostic methods fail. It is only too often that we see patients who give a history of "acute indigestion" in the past—an attack of severe chest pain after a heavy meal—for which they did not seek medical attention at the

time. I had one such patient who happens to have had, in addition, a history of an old duodenal ulcer, and in whom an electrocardiogram with a complete set of precordial leads was normal. I practically abandoned the diagnosis of an old coronary occlusion, but to my surprise I saw under the fluoroscope a large cardiac aneurysm. That was five years ago, and the patient is well and completely free from symptoms today in spite of a most alarming appearance of the cardiac shadow. Such a situation could well be repeated with massive calcifications proving the diagnosis of an old massive infarct.

The susceptibility to sudden death of patients with massive myocardial calcifications, as mentioned in the paper, will have to be interpreted with some caution. The fact that calcium was deposited in the scar proves that the infarcts have occurred in the distant past. It also should be pointed out that rupture of a cardiac aneurysm is an extreme rarity. Almost all cases of myocardial rupture are those with perforation of an area of recent necrosis. It is not at all unusual, though it is indeed surprising, to see at the autopsy table an old myocardial scar thinned out to paper thickness which stood the intraventricular pressure even in a hypertensive patient for many years. Perhaps patients with massive myocardial calcifications are not more susceptible to sudden death than others with coronary disease.

The point that some patients with a scar from a massive myocardial infarct gave no history of cardiac disease is of interest and fits in with the findings of our study of massive myocardial infarction which was carried out at Stanford (Arch. Int. Med. **82:** 196, 1948). A group of autopsied cases of recent fatal massive myocardial infarction is presented, and it is shown that the clinical course can be misleading because of benign symptoms and minimal signs of myocardial infarction. Such non-fatal cases could easily be missed or misdiagnosed.

Finally, it seems important to stress the point, brought out in the paper, that there may be confusion between myocardial and pericardial calcium deposits. Clinically, too, there are similarities between constrictive pericarditis and coronary disease with old myocardial infarction. In both conditions there may be chronic venous congestion with ascites, anasarca, and hepatomegaly, associated with little cardiac enlargement. Electrocardiographic changes in these two diseases are also not dissimilar. Now we know that calcium deposits along the left border of the heart could be located in the myocardium and not necessarily in the pericardium. It is obvious that, in a case presenting such signs and symptoms, a thoughtful and thorough differential diagnosis should be attempted before subjecting the patient to a thoracotomy for pericardiolysis.

Roentgen-Anatomical Studies of the Normal Ileocecal Valve[1]

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IN THE EARLY period of the development of roentgen diagnosis, the impact of new impressions and the urgency to use these in diagnosis led to important discoveries in the field of anatomy, physiology, and pathology, but at the same time there were often unfounded interpretations. It was soon recognized that a close correlation of roentgenologic observation with morphologic and functional facts was a prerequisite to the intelligent use of this new tool, and early research started in two directions. First, it was necessary to translate the details of the "shadow-pictures" into terms of normal and morbid anatomy. On the other hand, many significant details visualized by fluoroscopy or on roentgenograms were not given sufficient attention in the traditional anatomical and pathological descriptions, or were presented in such a way that correlation between roentgenogram and anatomical preparation was not feasible, and comparative roentgen-anatomical studies had to be undertaken to create the fundamental basis of roentgenology.

Stimulated by the increasing detection of disease of the ileocecal valve and adjoining structures and by the number and range of variations in this region, with no distinct borderline drawn between normal and abnormal, we have undertaken a comparative roentgen-anatomical study of this area.

The present paper deals with the normal ileocecal valve and its variations. A considerable amount of pathological material has also been accumulated due to the interest of the senior author (F. G. F.) in this problem, dating back to before 1928 (4), and this will be the subject of a later presentation.

MATERIAL AND METHOD

In fifty consecutive autopsies the apparently normal ileocecal area was removed *en bloc* after sectioning of the ascending colon and terminal ileum. The bowel was filled with formalin solution, tied off at both ends, and immersed in formalin for several days. In many instances, after this initial fixation, the specimen was filled with barium and an anteroposterior roentgenogram was taken to simulate the view obtained in a barium-enema examination. Thereafter, the barium within the specimen was evacuated and replaced by air so that double-contrast roentgenograms could be obtained.

As the next step, the specimens were opened by an initial incision from the upper cecum, along its lateral aspect, and the ileocecal valve projecting from the opposite medial wall was inspected, measured, sketched, and in many instances photographed. The incision was then extended in the coronal plane to reach the medial wall of the cecum and bisect the ileocecal valve and terminal ileal loop. Further measurements, drawings, and photographs were obtained of the posterior half of the specimen, which is most comparable to the clinical roentgenogram. In individual instances the dissection was modified in order to expose particular features. Histologic sections of the valve and its immediate vicinity were obtained in a considerable number of cases.

The clinical-roentgenologic material consisted of the accumulated files of spot films of the ileocecal region taken routinely in about 2,000 barium-enema examinations during the past three years; 200 of the spot-film series were selected for this study. These films were obtained with the use of a

[1] From the Department of Radiology, Beth Israel Hospital and Harvard Medical School, Boston, Mass. Read by title and presented as a scientific exhibit at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

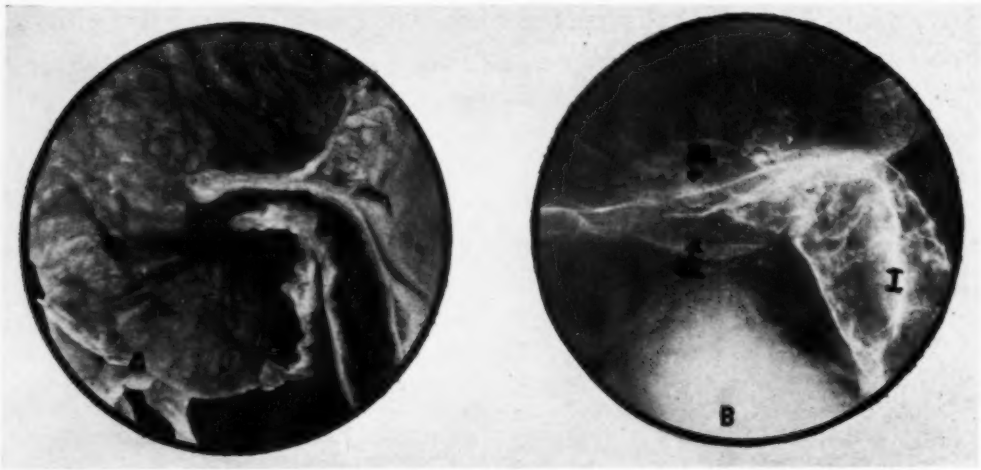
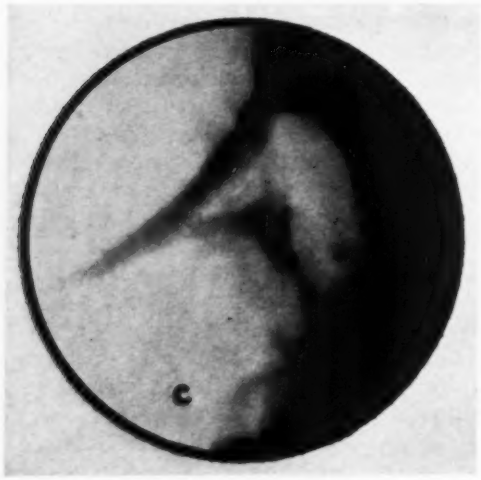


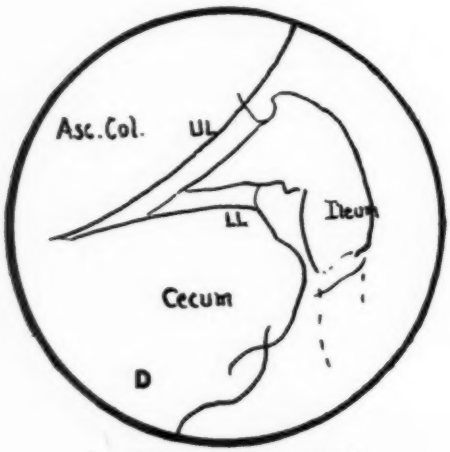
Fig. 1. The normal ileocecal valve

A. Coronal section of the ileocecum showing the average implantation of the terminal ileum, the overhanging upper lip, and receding lower lip.

B. Double contrast roentgenogram of another normal specimen. The upper lip extends into the posterior frenulum. I. Terminal ileum. UL. and LL. Upper and lower lips of valve.



C. Clinical roentgenogram of valve of average type.



D. Explanatory diagram for C.

regular commercial spot-film device, using a cone 7.5 cm. in width. As soon as barium entered the terminal ileum, either spontaneously or after some palpation, the cone was centered over the ileocecal valve and a varying degree of pressure was applied to expose the lips of the valve to best advantage. Several spot films were taken with the requisite degree of pressure and angulation to delineate the valve. Because of the common slightly oblique and posterior implantation of the ileum (as described later), the films were most often taken with the patient's left side slightly raised. In the event of failure of barium to enter the ileum, the valve could still be recognized as a spindle-shaped filling defect with a central barium-filled slit. In a few instances, the valve was studied three to five hours after a barium meal, by the

same spot-film technic (70 to 75 kv., 5 ma., 0.2 to 0.4 second).

The anatomic descriptions, illustrations, and specimen roentgenograms to follow refer to representative examples of the postmortem material, and the clinical roentgenograms and roentgenologic descriptions are from the selected normal cases, as mentioned above. Appropriate films have been chosen to match the anatomic material, and both will be presented in close correlation, classified, and grouped.

ROENTGEN-ANATOMICAL CORRELATION (FIG. 1)

The most common type of ileocecal valve has been chosen as the starting point for the description. The variations observed between the several distinct groups encountered will be discussed in later paragraphs.

(*Note:* We shall use *colon* as a general term, *cecum* to designate that portion of the colon caudal to the ileocecal valve, and *ascending colon* for the colon cranial to the valve. *Ileocecum* comprises the terminal ileum and the immediately adjacent portions of the cecum and ascending colon.)

The terminal loop of the ileum rises from the pelvis, forming a reverse S-shaped curve, approaches the colon at its medial aspect, and enters it at a right angle, projecting into its lumen as a papillary prominence. This prominence presents an oval appearance, with its longer diameter horizontal, and a central slit-like opening, pointed at either end. As noted by Buirge (3), however, the valvular aperture is not constant as to size or contour, and no correlation could be established between the size or shape of the opening and the type of valve.

The corresponding portions of the bluntly ending ileal walls are called the upper and lower lips (labia) and form the valve proper. The upper lip has an average length of 2.0 cm., measured from the colonic wall to its free edge; while the lower lip is usually shorter, its edge recessed from the upper edge for 0.3 to 0.5 cm. These ileal lips are 0.3 to 0.5 cm. in thickness.

The valve does not project freely into the colon but is supported and suspended anteriorly and posteriorly by crescent-shaped folds of the colonic wall, fixed structures but not haustral folds, called the frenula of the valve. They are usually level with the upper lip of the valve and together with it form a shelf-like horizontal projection extending into the lumen of the colon for a third or more of its diameter and representing the boundary between cecum and ascending colon. The posterior (lateral or right) frenulum usually extends across the posterior circumference of the colonic wall, sometimes reaching the lateral wall; and the anterior (medial or left) frenulum is commonly smaller.

Since the ileum is usually implanted into the colon immediately anterior to or within the medial (mesenteric) tenia, this tenia stiffens the base of the valve, while the other teniae lend considerable support to the frenula.

The main supportive structure of the lips of the valve is a muscular layer which is a continuation of the muscularis propria of the ileum and colon. As the ileum enters the colon, the serosa bridges the angles of apposition, and muscle layers of ileum and colon fuse to form circular and longitudinal layers of muscle, the longitudinal fibers of colonic origin being derived from the mesenteric (medial) tenia (2). In some instances, thin muscle fascicles were found bridging the upper angle between ileal and colonic walls, corresponding to the root of the upper lip. The muscle layers of the lips extend very close to their free edges, across their entire width, and are surrounded above and below by loose areolar tissue forming the submucous layer (Fig. 2).

There is a continuous covering of mucosa over the lips; the mucosa on the inner surface has villi and the characteristics of ileal mucoa, while that on the outer surface has no villi but numerous goblet cells peculiar to the colonic mucosa. The transition in mucosal structure occurs at

Fig. 2. Photomicrograph of ileocecal valve with lips of average architecture. ×2.5. (Gross specimen shown in Fig. 6A.) The upper lip is seen to be made up of the joined inverted colonic and ileal walls. The muscle layer, the interrupted dark central band, is the extension of the fused muscularis propria of the colon and ileum. The arrow points to the transition from ileal to colonic mucosa. The lower lip, in this case almost perpendicular to the upper lip, has essentially the same structure.

the free margin of the lips, usually rather distinctly at the level of the muscular layer.

It should be noted here that we use the term "ileocecal valve" as an anatomical term throughout, recognizing that it is a structure acting not only mechanically but also as a true sphincter, regulating the transit of ileal contents into the cecum and preventing, under normal conditions, reflux of cecal content into the ileum (1, 10).

Roentgenologically, the most common type of ileocecal valve presents itself as follows: The homogeneously barium-filled terminal ileal loop arises from the right pelvis in a smooth, shallow, reverse S-shaped curve; it is often slightly widened immediately before it enters the colon, while its projecting end narrows down to a point. This portion of the terminal ileum has often been compared to a bird's beak or a funnel (5). In such an average case, the roentgenogram taken with slight or no compression (Fig. 1C) reveals two clear-cut band-like areas of increased radiance, each about 3 to 5 mm. in width, resembling a pair of lips as seen in profile (9) and continuing the contours of the free ileal loop to converge within the colonic lumen. Quite often the filling defect caused by the upper lip can be followed, particularly when more pressure is applied, far beyond the edge of the lower lip, almost to or even as far as the lateral wall of the colon. This extension of the shadow of the upper lip corresponds to the posterior frenulum of the ileocecal shelf. The lips of the valve contain between them an elongated triangular collection of barium corresponding to the lumen of the valve, usually 1 to 2 mm. in height but occasionally opening to a greater extent.

In considering the variations from this most common type of ileocecal valve, as described above, the following major aspects will be discussed:

1. Shape of the terminal ileal loop and its approach to the cecum.
2. Extent of the common ileocolonic wall and its influence upon the roentgenologic appearance.
3. Formation of the lips of the valve as to length, thickness, and shape.
4. Borderline features between the normal and pathological valve.
5. The mucosa of the terminal ileum and the valve.

Shape of the Terminal Ileal Loop and Its Approach to the Cecum: The reverse S-shaped ascending terminal ileal loop is by far the most common, occurring in about 95 per cent of our material. In a few of our clinical cases, and in two of our anatomical specimens, the ileum was seen to approach the colon in the horizontal plane. This does not include cases with marked obesity or peritoneal fluid, where most of the ileal loops are often found in an unusually high location instead of being assembled within the pelvis. In rarer instances, the terminal ileum approached the colon from above and it was difficult to decide whether this arrangement was caused by peritoneal adhesions or represented a normal variant. There are two

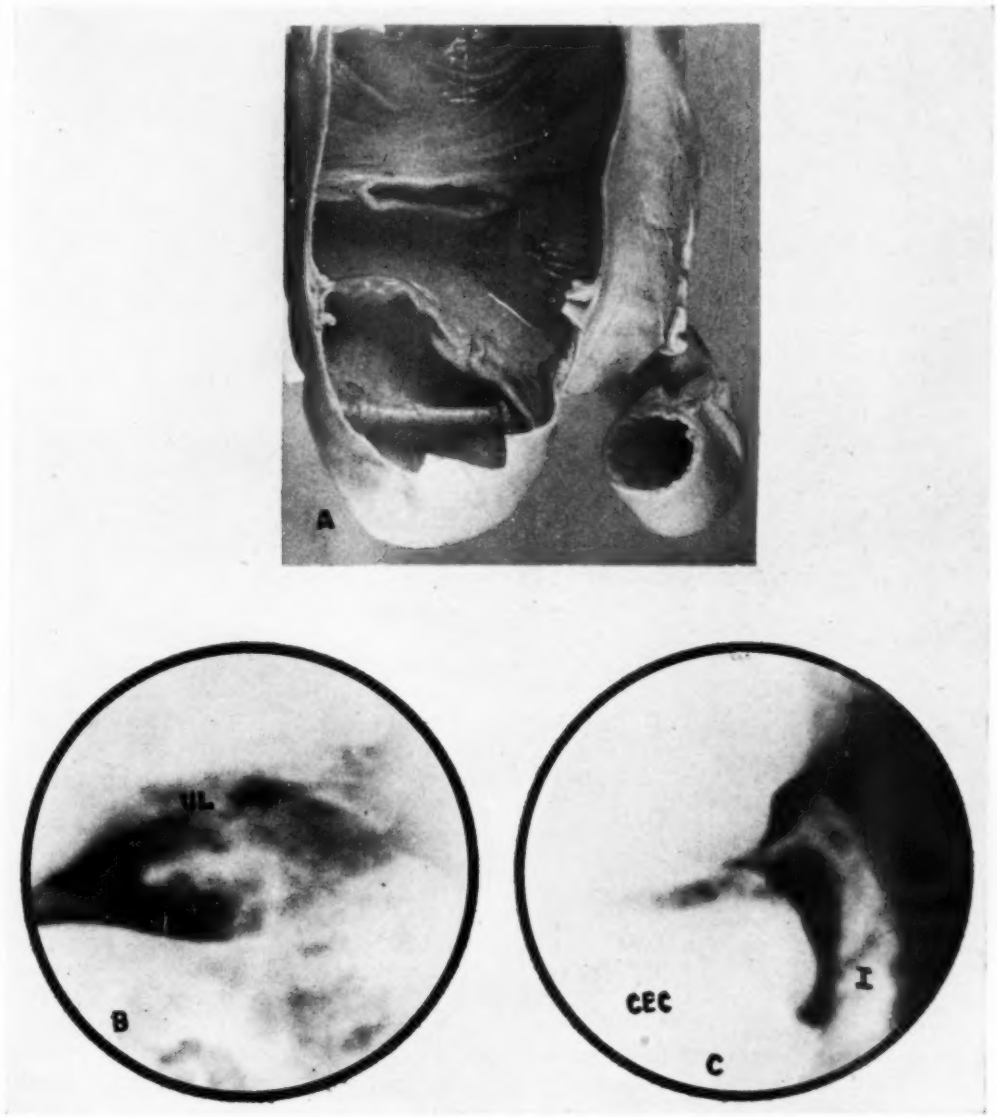


Fig. 3. Posterior implantation of ileum

A. Photograph of cecum opened by anterior window. The lips and slit opening of the valve appear across the posterior wall.

B. Clinical roentgenogram with compression, postero-anterior view. The spindle-shaped filling defect represents the head-on view of the lips; the white irregular band along the axis of the spindle indicates the opening of the valve.

C. Same case in an almost left lateral view. Valve appears in the customary fashion.

types of implantation from above, in one of which the colon is in normal position, while in the other somewhat more common type the colon is turned medially, either permanently fixed or movable on a free mesentery.

The insertion of the ileum into the colon usually occurs from the medial and slightly

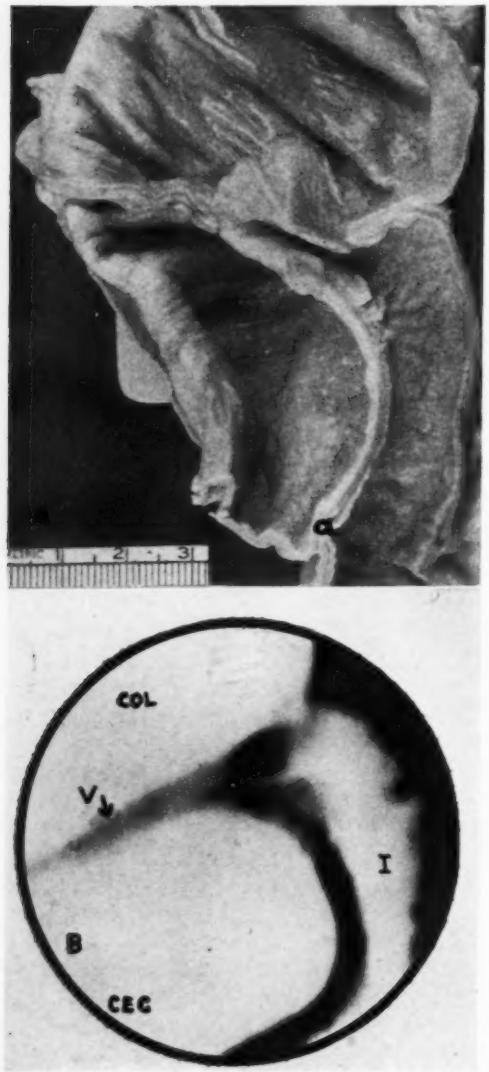


Fig. 4. Extensive fusion of ileal and cecal walls.
A. Photograph of coronal section of ileocecum, posterior half. The long joint wall of cecum and ileum, starting at letter *a*, curves gradually into the lower lip. The upper lip is widened (upper contour retouched).
B. Corresponding clinical roentgenogram demonstrating the even spacing between ileum and cecum.

dorsal aspect but may be in the direct coronal plane. In 7 per cent of cases, there is direct implantation of the ileum into the posterior wall of the colon, and on roentgen examination the visualization of the valve assumes a particular form. Not detectable along the left contour of the colon, it is best visualized by compression of the fully filled colon, or less often with an incompletely filled colon. A spindle-shaped filling defect, 1.0 to 2.0 cm. wide, is visible across the cecum, with a thin line of barium, 2.0 to 3.0 cm. in length, across its horizontal axis, representing the narrow gap between the edges of the lips. The appearance is exactly that of the common type of valve seen with rotation of the patient so that a head-on view is obtained (Fig. 3). Conversely, if the posterior insertion type of valve is viewed in profile, by turning the patient through 90 degrees, the approach and appearance of the terminal ileum and valve are identical with the "standard." Least frequently, a more anterior insertion of the ileum was found, best visualized in profile with the patient in a right oblique position.

In those exceptional instances of insertion into the right colonic wall, there was always a history of previous appendectomy or other abdominal operation, or evidence of other disease in the right lower quadrant, so that we do not consider this type of implantation within normal limits.

In our material, no correlation was noted between the position of the lower lip of the valve and changes in form or direction of the terminal ileum (8).

Extent of the Common Ileocolonic Wall and Its Influence Upon the Roentgenologic Appearance: With the ileum forming a rather wide curve and approaching the colon at a right angle, the fused parts of the ileal and colonic walls form the lips of the valve, and the extent of these fused walls is identical with the length of the lips. In many instances, however, the fusion of the ileal and cecal walls starts at a much lower level, the ileum being closely attached to the medial side of the cecum. For practical roentgenologic reasons, it seems useful to designate as lips only that portion of the fused wall which projects into the lumen of the colon, and consider separately the remainder. In this respect the following description deviates from those found in major anatomical texts.

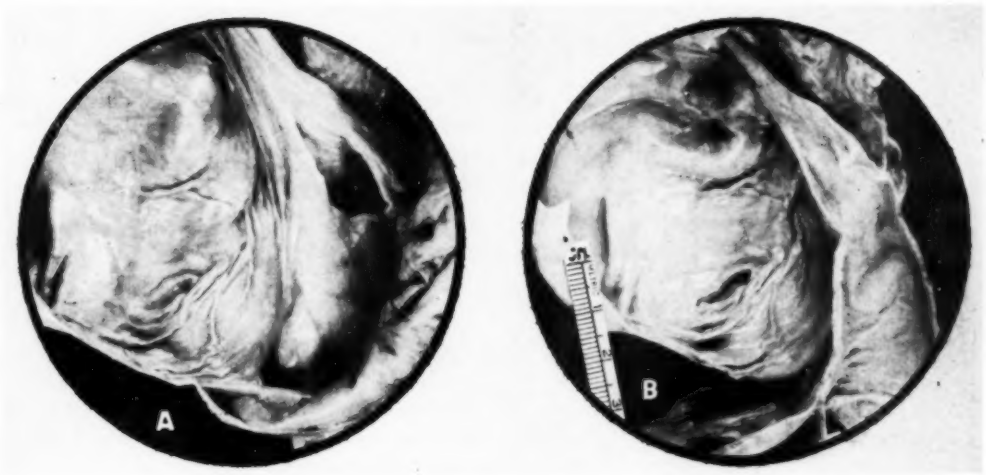


Fig. 5. A. Photograph of cecum opened anteriorly. The roll-shaped projection in the right half of the picture is the terminal ileum protruding into the lumen of the cecum. The black diamond-shaped figure at the top of the roll is the ileocecal opening.

B. Ileum opened by an incision extending from the ileocecal opening downward, exposing the joint ileocecal wall.

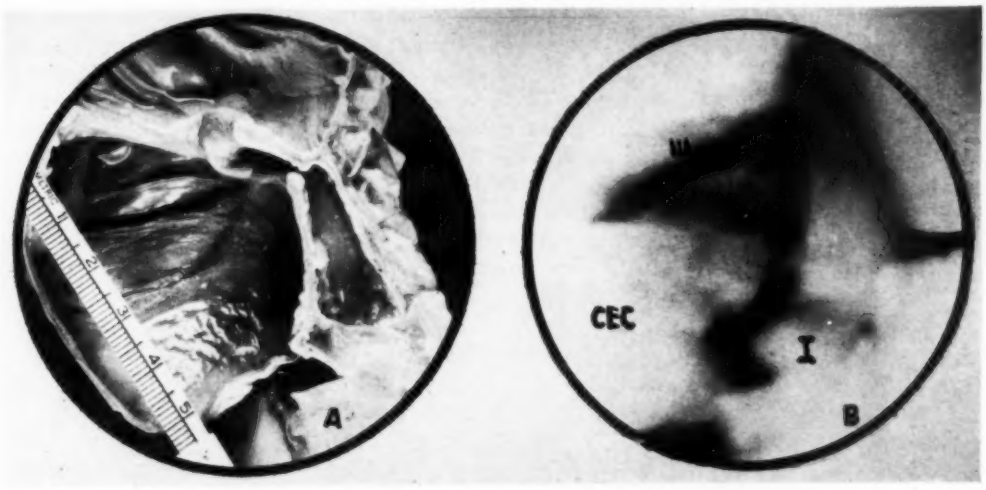


Fig. 6. Short lower lip

A. Photograph of coronal section of ileocecum, posterior half, demonstrating a joint ileocecal wall perpendicular to the upper lip, without any true lower lip formation.

B. Corresponding clinical roentgenogram.

The fusion occurs to a greater extent between the lower (right) ileal and cecal walls than it does between the upper (left) ileal and ascending colonic walls, and we have quite often found such a fused lower wall, 2.0 to 3.0 cm. in length, among our specimens (Fig. 4). In one instance (Fig. 5) this common wall had an extent of 5.0 cm., and since this variation assumes roentgen diagnostic significance, it seems justifiable to discuss it in detail. From the outside, an unusually long portion of the terminal ileal loop could not be separated from the colon. On opening the cecum, a

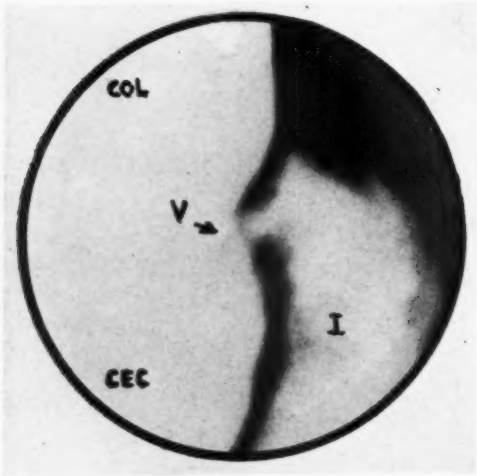


Fig. 7. Clinical roentgenogram of an ileocecal valve with very short lips.

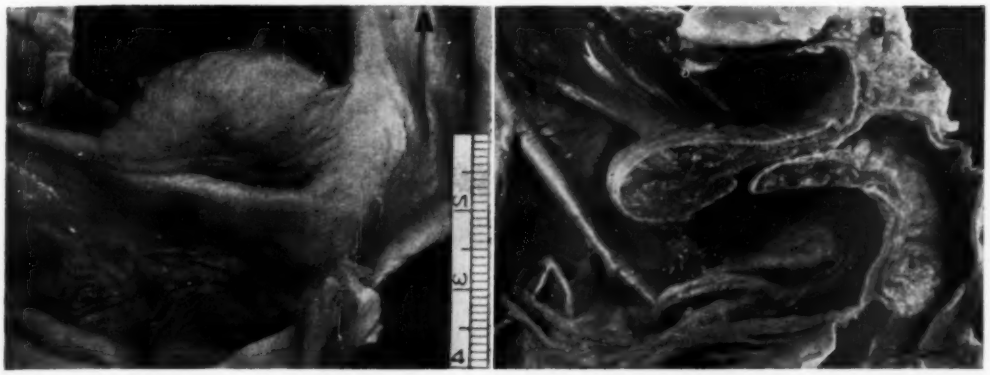
small shelf and a roll-shaped protrusion were seen at the medial wall of the cecum, corresponding to the closely attached ileum. There was hardly any true valve formation; instead, this protrusion showed a diamond-shaped opening at its upper end which led into the ileum. On dissecting the medial wall of the cecum downward from this opening, the fused wall between ileum and cecum was exposed. There was no anatomical evidence of inflammatory scarring, while the almost intracecal protrusion of the ileum and the formation of the valve opening further supported the congenital nature of this arrangement.

In clinical roentgenology one occasionally encounters instances in which the terminal ileal loop is closely attached to the medial cecal wall. The barium-filled ileum and cecum are evenly separated from each other for 2 to 3 mm. and cannot be further separated by palpation. This appearance suggests that ileum and cecum are bound together, from which the conclusion is drawn that there is a pathological adhesion. As a result of our anatomical studies, we consider such an arrangement normal so long as the spacing between ileum and cecum is even in width, with both adjoining contours smooth and parallel (Fig. 4B). If this is not the case, we regard it as an abnormal adhesion.

In the majority of cases, the common lower ileocecal wall bends medially to form a real lower lip of the valve, approaching the upper lip at an acute angle and ending a few millimeters short of it. In some instances this common ileocecal wall ends in an upward direction, with a blunt termination representing the extremely short lower lip, perpendicular to the upper lip of the valve (Fig. 6).

The fused portion of the upper extralabial ileocolonic wall is usually short—

Fig. 8. Coronal sections of ileocecal specimens showing two extreme variations: (A) unusually thin lips and (B) extremely thick lips. (Fig. 1A, the most common average type, would lie between these two extremes.)



about 1.0 cm. in length and often shorter. Its length may occasionally be as much as 2.0 cm., in which case the left ileal wall extends further upward, forming a pouch-like recess at the bend of the ileum.

Formation of the Lips of the Valve as to Length, Thickness, and Shape: The valve lips are designated as the salient portions of the common ileocolonic wall which extend into the colon, and the length of the upper lip can be measured with reasonable accuracy due to the sharp angle or curve at which it juts from the colonic wall. We found its average length to be 2.0 cm. and the maximum length 4.0 cm.

In rare instances, there is hardly any projecting upper lip, since the ileal and colonic walls fuse and end in a blunt fashion almost at the plane of the medial colonic wall. When, in such cases, the lower lip is similarly formed, there results what may be called an ileocecal opening rather than a true valve. Roentgenologically this type shows a very short, shallow, wide-funneled opening, without any lip extending into the cecum, even on compression (Fig. 7).

The length of the lower lip often cannot be definitely measured because of the fact that the medial wall of the cecum gradually curves inward as it approaches the valve and no definite origin or root of the lip can be distinguished, any location chosen being necessarily arbitrary. Usually, however, the free edge of the lower lip is recessed from the free end of the upper lip for a distance of 0.5 cm. and it is considered the shorter lip.

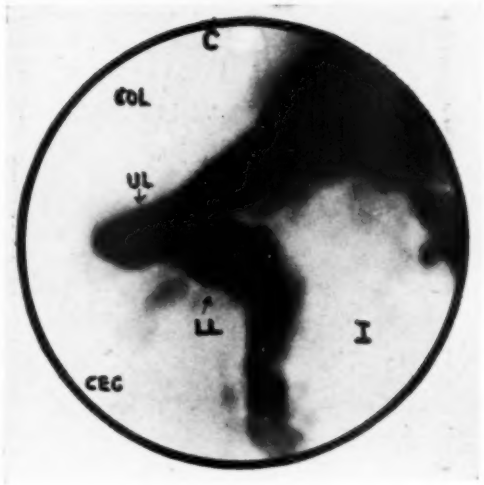


Fig. 9. "Shark-mouth" type.
A. Photograph of cecum opened anteriorly to show the ileocecal valve from its lower surface. The plump projecting upper lip, the receding lower lip, and the slit-like opening between are well exposed.
B. Coronal section of the same specimen demonstrating the relation of the lips.
C. Corresponding clinical roentgenogram.

The upper and lower valve lips are generally similar in thickness, measuring 3 to 5 mm., with their blunt free edges often slightly plumper. Quite frequently, there is marked clubbing of the distal portions, while in a minority of cases general increase in thickness throughout the lip occurs. Figure 8 shows some common variations.

Increase in width is almost always due to a marked accumulation of adipose areolar tissue, usually arranged at the

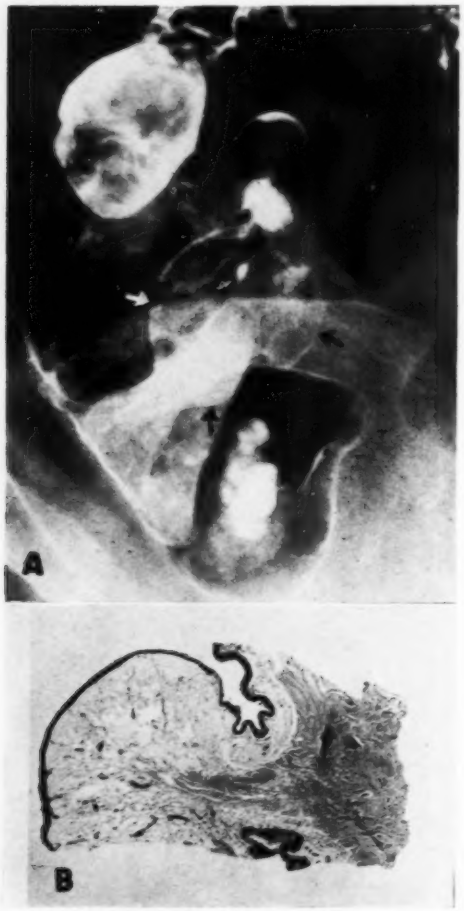


Fig. 10. Plump adipose lips of the valve.
A. Clinical roentgenogram of a case of carcinoma of the colon with the incidental finding of a rounded mass at the ileocecal valve (arrows).
B. Photomicrograph of the upper lip of this valve, the specimen including the upper two-thirds of the valve. The ileal mucosa is visible for only a short distance at the lower cut edge of the specimen. The unusually enlarged lip is mainly adipose tissue. ×2

colonic aspect of the lip. The muscle layers may occasionally also show some thickening. As a remarkable feature, it was found that the muscle plate splits up into two or three layers toward the free edge of the thickened lip, apparently providing a sufficient support for the lip and at the same time indicating how the lip as a whole still exerts its sphincteric function, in spite of its plumpness. An extreme instance of this type is shown in Figure 9. Here the plumpness of the lips combined with a marked recession of the lower lip serves to locate the opening of the valve far back at its undersurface, and "shark-mouth" type is the most apt descriptive designation.

In some instances this accumulation of fatty tissue is excessive, resulting in a tumor-like swelling, mainly of the upper lip, and presenting difficulties in the roentgenologic differential diagnosis, which will be discussed in the following section.

Borderline Features Between the Normal and Diseased Valve: General attention to thickened adipose lips of the ileocecal valve was first stimulated by the observations of Ross Golden (6), two of whose cases may be reviewed briefly here:

(1) A filling defect was seen about the ileocecal junction, sufficiently large to suggest ileocecal intussusception. There were no symptoms referable to disease in that region. At operation, edema of the terminal ileum and the mucosa of the valve were found. No resection or excision was performed.

(2) In the second case the roentgenologic findings were similar. At operation, the valve was found to be enlarged, secondary to edema of the ileal mucosa. In this case there was regional ileitis.

These cases were followed by an observation made at the Massachusetts General Hospital (11):

Roentgen examination showed a large rounded polypoid filling defect with a broad base projecting from the bowel wall into the lumen, from the lateral aspect. The ileocecum was resected and a submucous lipoma of the ileocecal valve found. In the discussion, however, Dr. Castleman stated that he "was not sure it could not have been merely a variation from the normal ileocecal valve.

We have encountered another case of this type, the second with pathological proof (Fig. 10).

The patient was a white female, 65 years of age. A carcinoma of the ascending colon was diagnosed and, in addition, some of the films showed a rounded, well defined mass connected with the ileocecal valve. The resected specimen showed the ulcerated carcinoma and, independently, a thick, spindle-shaped upper lip of the valve, bright yellow in color. Microscopic section through the upper lip showed excessive adiposity without signs of neoplasm or inflammation.

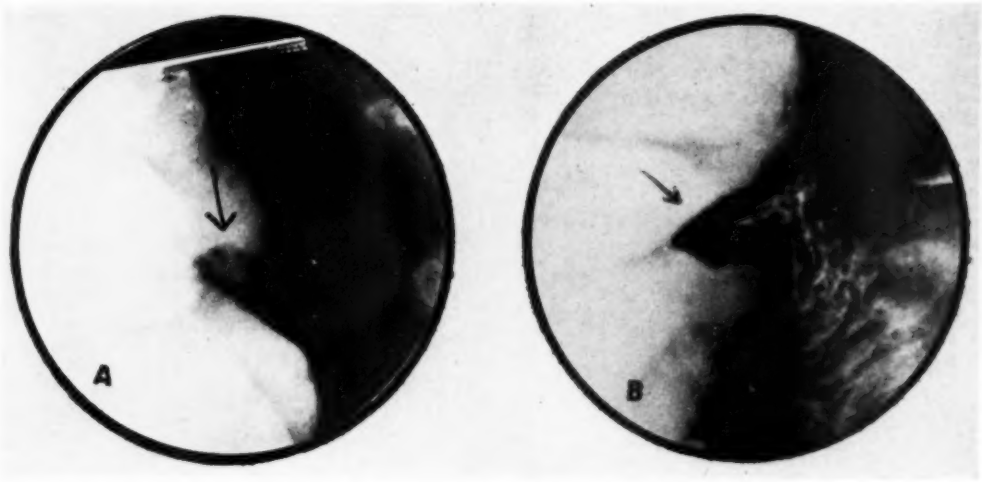


Fig. 11. Star-shaped mucosal pattern: head-on (A) and lateral (B) views. (Courtesy Dr. L. G. Rigler)

There are instances of extreme adiposity of the upper valve lip, possibly also of the lower lip, which grossly and roentgenologically appear as smoothly outlined masses up to 2.0 cm. in diameter. Their intimate relationship to the valve can usually be established roentgenologically and should be sought for. If there is no local tenderness or any other sign of abnormality in the ileocecum, it has become our policy, in view of the above-mentioned observations, to refrain from diagnosing a pathological condition. We believe that in such instances the indication for surgery must rest solely on clinical and not roentgenological evidence, including exploratory laparotomy in an otherwise doubtful case.

The Mucosa of the Terminal Ileum and Valve: Anatomical and roentgenologic texts describe the mucosa of the terminal ileum as flat, with no particular mucosal pattern visible in the relaxed bowel. Occasionally shallow longitudinal or irregular folds may be observed, changing their pattern with the widening and narrowing of the bowel segment and the passing contraction waves. When "proceeding contractions" in the terminal ileum (Oppenheimer, 9) set in, the mucosa forms slender longitudinal folds in the narrowed portions, which may well represent mainly a passive adjustment to the narrowed lumen. We have seen these folds converge and fade out at the entrance of the ileum into the colon, or at the base of the valve lips.

Occasionally, an axial view of the lumen of the valve may be obtained, presenting a star-shaped or rosette-like pattern corresponding to similar observations in head-on views of the pylorus and base of the duodenal cap and the cardia. Our attention was called to this by Dr. Leo Rigler, to whom we are indebted for a set of roentgenograms illustrating this condition (Fig. 11).

Transverse folds of the pattern normally occurring in the upper small intestine may also be observed in the lower ileum. Many concepts of the normal anatomy and physiology of the gastro-intestinal tract, based on postmortem dissection, have been changed in the light of roentgenologic observation in the living. However, while the functional nature of the haustration of the colon has been fully recognized, anatomical texts still state that the plicae conniventes of Kerkring are permanent morphological structures, that they occur in the upper small intestine and are absent in the lower ileum. This appears to be not entirely correct for the living.

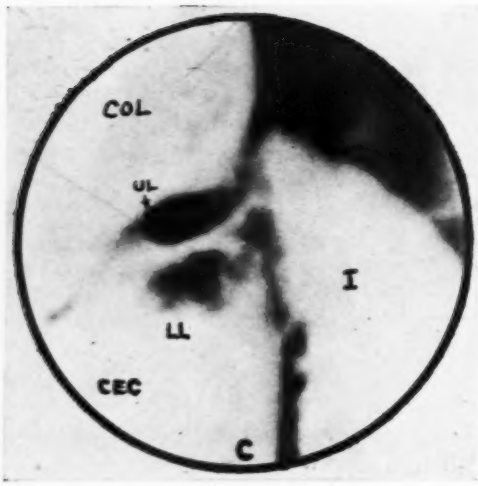


Fig. 12. Protrusion of ileal mucosa.
A and B. Head-on and coronal views of valve with protrusion of the ileal mucosa forming a rosette-like collar. (Contours of herniated mucosa have been retouched.)
C. Corresponding clinical roentgenogram demonstrating bulky lips with lobulated contours.

The heaping up of the mucosa into Kerkring's folds appears to be the inherent pattern of the entire small bowel. In the adult these folds are almost always present in the duodenum and jejunum, although their pattern changes during contractions. In disease, particularly inflammation, they may temporarily disappear. In children they may disappear, also, with distention, to reappear as soon as the bowel recovers its width and tone. According to the traditional teaching, these folds are ordinarily not visible in the resting or quietly functioning lower ileum; they are, however, frequently present in the pathologically irritated ileum. We believe that we have seen them also, occasionally, in perfectly healthy persons, and it seems probable that the muscularis mucosae throws the mucosa into folds of this inherent pattern in a transient fashion during increased motor activity within normal conditions. With disease in the ileocecal region, this pattern is found with great frequency, and correspondingly in surgical specimens of this region these folds are frequently present unless inflammation or neoplasm has grossly destroyed the mucosa. Published photographs of such specimens often clearly demonstrate these folds (Golden, 6, p. 138, Fig. 39B). It has therefore been our attitude, whenever Kerkring's folds are persistently visible in the lower ileum, to look for a gross lesion in the ileocecal region, and to consider their presence in doubtful instances as supportive evidence of disease.

The mucosa of the lips is often loosely attached to the underlying structures, and this is particularly true for the ileal, inner surfaces of the valve. In several of our anatomical specimens there was protrusion of the ileal mucosa beyond the

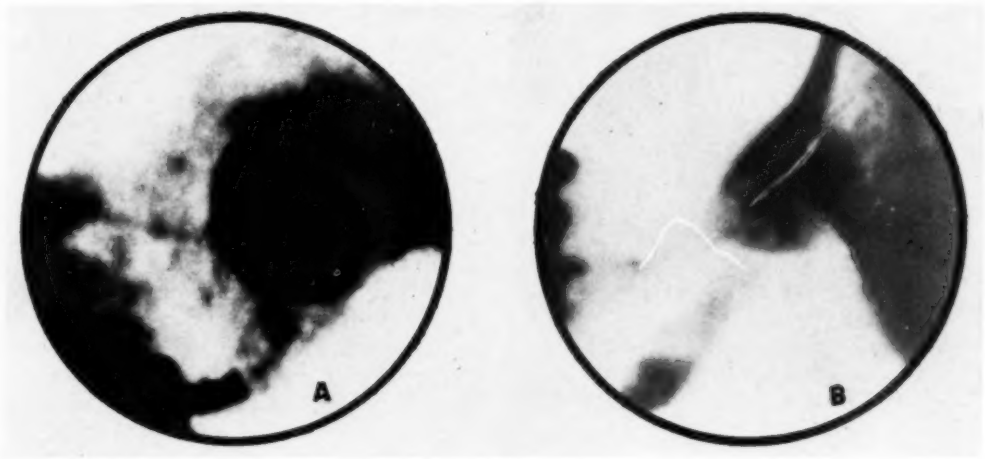


Fig. 13. Massive intracolonic herniation of ileal mucosa (clinical roentgenograms).
A. Taken with marked compression, showing a large filling defect at the medial aspect of the ceco-colonic junction.
B. The same with less pressure, revealing the relation of the mass to the valve. (The white line representing the slit-like lumen of the valve has been retouched.)

opening of the valve, producing a rosette-like valve rim (Fig. 12). Histological sections of such lips revealed that the transition from ileal to colonic mucosa occurred on the colonic side of the lip rather than at its edge, confirmatory evidence that the mucosa was protruded or herniated. This mucosal herniation appears usually to have no clinical significance and may be similar to transpyloric herniation of gastric mucosa. However, marked instances of this herniation may represent an early stage of, or indicate, true ileocecal intussusception. It is interesting in this regard to note that Leichtenstern in 1873 and D'Arcy Power in 1897 pointed out that prolapse of the mucous membrane of the ileum into the colon was apparently the beginning of a large number of ileocecal invaginations (7). Hellmer's views, set forth in his recent work on "Roentgenologic Diagnosis of Intussusception in Children (7), are in accord with these observations and with our impression.

The following case is illustrative of this occurrence in an adult:

A. F., a 57-year-old white female, gave a history of intermittent right lower abdominal pain over a six-month period. Roentgen examination revealed marked "swelling" of the lips of the ileocecal valve, forming a mass 4.0 cm. in diameter. At operation a fold of mucosa and submucosa was found, which had telescoped through the ileocecal valve into the cecum; this was reduced. No other abnormality was present; no true tumor was found (Fig. 13).

We do not believe it possible, on roentgenologic evidence, to distinguish between such prolapsed mucosa and a structurally plump lip unless the filling defect changes in size or shape during one examination, or on repeated examinations, which would be in favor of prolapse.

The topographic relationship of the apparent mass to the valve should be closely determined in order to avoid misrepresentation, as illustrated by the cases of Golden (6) and the Massachusetts General Hospital (11)—reported in some detail above—where the ileal protrusion was not recognized as such. In both of these reported cases there was posterior implantation of the ileum into the colon, so that the filling defect caused by the protruding valve presented itself laterally and distant from the usual site of the valve.

Reflux of colonic content into the ileum, as well as non-reflux, has formerly been considered pathological. It is now established that under the conditions of a barium-enema examination, particularly

Fig. 14. "Cobble-stone" pattern of the terminal ileum.

with sufficient distention and palpation of the cecum, colo-ileal reflux can be observed in approximately 90 per cent of normal individuals. In such cases, the valve lips appear roentgenologically to be almost touching each other, with the barium entering the ileum through the slit-like opening between them, which does not measure more than 2 or 3 mm. in height. In only a few cases have we been able to obtain spot films showing this opening to measure 0.5 cm. or more, and in these the lumen rapidly returned to its usual small size. In practically all instances of a persistently patulous valve, there was clinical evidence of disease (regional enteritis, acute or chronic colitis, tuberculosis, etc.), substantiated by surgical or pathological examination in the majority of cases.

In the presence of reflux, the barium stream may carry inspissated fecal material into the ileum, causing a mottled pattern or larger distinct filling defects. The observation of the retrograde passage, the mobility of the visualized filling defects, and failure to reproduce a similar appearance in a repeat examination should permit the differentiation of this occurrence from true lesions in the terminal ileum.

Contrasting with these usually easily recognized false irregularities in the appearance of the mucosal pattern of the terminal ileum, there occurs a finely or grossly nodular mucosal pattern—apparently inherently related to changes in the mucosa of the terminal ileal loop—described by Golden (6) as a "cobble-stone" pattern. In these cases, the terminal ileal loop is studded with rounded, often confluent, filling defects, both central and marginal (Fig. 14). Golden's interpretation, based on follow-up observations over a period of several years, is that of non-sclerosing ileitis. Our conclusions are in full accord with this opinion, but the definite nature and significance of these changes are not yet fully established because of the lack of pathological material in cases with careful roentgenologic studies. The majority of our observations concerning this entity were in patients in the younger age group, so that there may be some relation to the distribution of lymphoid tissue, as discussed in the following paragraph.

THE ILEOCECAL VALVE IN CHILDREN

The ileocecal region is rich in lymphoid tissue, which occurs in the mucosa, submucosa, and in large groups of lymph nodes in the ileocecal angle and along the appendix. Children are apt to respond to all types of infections with reactions in the lymphoid tissue, but in a given case it is often difficult for the pathologist to draw a sharp line of demarcation between the normal and the pathological state. Dr. Josephine Wells, in her recent report on this subject (12), emphasized the difficulty of obtaining verification of roentgenologic findings in this area by pathological material. Our knowledge of the ileocecal region in children is still incomplete, and many more observations must be accumulated in order to provide a reliable diagnostic basis for evaluation of any case. The varying amount of lymphoid tissue and the looseness of the submucous tissue as encountered in children seem to be the major factors influencing the appearance of the valve and require further investigation.

CONCLUSIONS AND SUMMARY

1. A comparative roentgen-anatomical study of the ileocecal valve has been undertaken on the basis of 50 normal postmortem specimens and selected roentgenograms from approximately 2,000 clinical examinations.

2. Many variations in the morphology of this region have been encountered and described. Distinct types could be observed, the prevailing pattern of which presented the following roentgenologic appearance: the terminal ileum rising from the pelvis in a reverse S-shape is implanted into the medial colonic wall, projecting into the colonic lumen for 2 cm. This intracolonic area, representing the valve itself, is flattened so that it forms a wedge-shaped lumen, opening through a horizontal slit into the colon. The upper and lower walls of this flattened area are the upper and lower lips of the valve, seen as band-like negative shadows, 3 to 5 mm. in width, converging toward the center of the colon. The barium-filled area between the lips varies from an elongated evenly calibered channel to a short plump cone. The upper lip is longer than the lower lip and fuses with the posterior shelf (frenulum) so that the filling defect caused by the upper lip extends almost to, or even as far as, the lateral wall of the colon. All these details are best observed by application of pressure.

3. When the ileum is implanted into the posterior wall of the colon, the valve presents itself head-on in the postero-anterior view. With pressure applied, a plump spindle-shaped negative shadow is seen, often extending across the entire width of the colon or sometimes even centered more laterally. A linear barium density in the axis of the spindle represents the opening of the valve. As a patient is rotated to the oblique or lateral position, the typical customary appearance of the valve described above becomes evident.

4. The lateral wall of the terminal ileum and the medial wall of the cecum may be fused over a fairly long distance. If the spacing between ileum and cecum is even in width, with both contours smooth and parallel, this is considered a normal variation rather than the result of inflammatory adhesion.

5. An excessive accumulation of fatty tissue in the lips of the valve, or protrusion of ileal mucosa beyond the lips of the valve, may cause a rounded tumor-like filling defect in the colon. Recognition of these instances as normal variations rests upon the intimate relationship of the mass to the valve; the smooth rounded contour; the lack of obstruction, local tenderness, or other sign of abnormality in the ileocecum; and the change in size or shape (with herniated mucosa). However, this distinction is not always possible, and in such instances the final decision rests on clinical evidence.

6. Insertion of the terminal ileum into the lateral colonic wall is considered not to be within the normal range of variation.

7. Persistently visible Kerkring's folds in the terminal ileum occur with disease in the ileocecal region and their presence should arouse suspicion of the presence of an associated lesion.

NOTE: We wish to express our thanks to Dr. Leopold Reiner, assistant pathologist, for his help in obtaining the anatomical specimens and his advice in the histologic part of our study.

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SUMARIO

Estudios Roentgeno-Anatómicos de la Válvula Ileocecal Normal

1. Este estudio roentgeno-anatómico comparado de la válvula ileocecal tiene por base 50 ejemplares autópsicos normales y radiografías seleccionadas entre unos 2,000 exámenes clínicos.

2. Muchas variaciones morfológicas de esta región han sido observadas y descritas. Notáronse ciertas formas bien definidas, cuyo patrón dominante presentaba el siguiente aspecto roentgenológico: la porción terminal del ileon, elevándose de la pelvis en una S invertida, se halla implantada en la pared de la porción medial del colon, proyectando 2 cm. en la luz del último. Esa zona intracolónica, que representa la válvula misma, está aplanada, de manera que forma una luz cuneiforme que desemboca en el colon a través de una hendedura horizontal. Las paredes superior e inferior de esa zona aplastada constituyen los labios superior e inferior de la válvula, observados en forma de sombras negativas parecidas a franjas, de 3.0 a 5.0 mm. de ancho, convergiendo hacia el centro del colon. La zona llena de bario entre los labios varía en aspecto de un conducto alargado de calibre uniforme a un cono corto y grueso. El labio superior es más largo que el inferior y se confunde con el frenillo posterior, de modo que el nicho ocasionado por el labio superior se extiende casi por completo o del todo hasta la pared lateral del colon. Todos esos detalles se observan mejor aplicando presión.

3. Si el ileon se halla implantado en la pared posterior del colon, la válvula se presenta de cabeza en la vista postero-anterior. Al ejercer compresión, obsérvase una sombra negativa fusiforme y rolliza, que a menudo se extiende a través de todo el ancho del colon o a veces se centra hasta más al lado. Una condensación lineal de bario en el eje del huso representa la abertura de la válvula. A medida que se rota al enfermo a la posición oblicua o lateral, se pone de manifiesto el típico y habitual aspecto de la válvula descrito más arriba.

4. La pared lateral de la porción terminal de ileon y la de la porción medial del ciego pueden confundirse por una distancia bastante larga. Si el espacio entre el ileon y el ciego muestra un ancho uniforme y ambos contornos son lisos y paralelos, se acepta esto como variación normal más bien que efecto de adherencias inflamatorias.

5. Un acúmulo excesivo de tejido adiposo en los labios de la válvula, o la protrusión de la mucosa ileal más allá de estos labios, puede ocasionar una deformación redondeada y parecida a tumor en el colon. La aceptación de esas manifestaciones como variaciones normales reposa en: la íntima relación de la tumefacción a la válvula; el contorno redondeado y liso; la falta de oclusión, hiperestesia local u otro signo de anomalía ileocecal; y el cambio de tamaño o forma (con herniación de la mucosa). Sin embargo, no es posible hacer siempre esa distinción, y en esos casos, el fallo definitivo se asienta en los datos clínicos.

6. La inserción de la porción terminal del ileon en la pared lateral del colon no se considera como parte de los límites normales de variación.

7. Hay persistente visibilidad de los pliegues de Kerkring en la porción terminal del ileon en las afecciones de la región ileocecal y su presencia debe avivar sospechas de la existencia de una lesión concomitante.

Fast Radiological Visceral Survey[1]

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CHEST SURVEYS by means of miniature films have been very useful in the detection of early cases of tuberculosis. This has stimulated medical and general interest in surveys of various kinds, and especially in those surveys for the detection of hidden cancer in its operable phase. There is no doubt that such surveys have their place in preventive medicine, but one must recognize the dangers of investigations confined to a single organ or to a single part of the body. A negative result may give the patient a false sense of security, and such surveys may lead us to disregard the patient as a whole and to forget the important fact that he may be suffering from more than one disease. Good medicine today depends on the integration of several clinical investigations and laboratory procedures. During the course of a "general examination" roentgen procedures do not remain isolated. The search is not limited to a single organ nor to a single disease but often extends to all the accessible viscera. This type of roentgen procedure can well be called a radiological visceral survey.

A radiological visceral survey is part of a general examination. Such examination is initiated by a physician who, after a thorough history and physical examination, requests a series of consultations, laboratory tests, and roentgen procedures. When this work is completed, the physician summarizes the findings, integrates them with his own, arrives at a diagnosis, and prescribes the treatment. Obviously, this method, because of the time and cost involved, is not susceptible of mass application but is reserved for difficult diagnostic cases and for those patients in whom it is necessary to exclude organic pathology. Such cases constitute about a fifth of the patients seen for the first time by our group and well over 50 per cent of the work of the radiological section.

TABLE I: EXAMINATIONS REQUESTED IN 100 CONSECUTIVE "GENERAL EXAMINATIONS"

Consultations	
Allergy	1
Proctology	16
Heart	5
Ear, nose, throat	13
Dental	23
Gynecology	14
Neurology	4
Eye	14
TOTAL	90
Laboratory tests	
Urine	94
Complete blood count	85
Sedimentation	93
Basal metabolism	11
ECG	49
Kahn test	73
Others	87
TOTAL	492
Roentgen procedures	
Chest	87
Gallbladder	79
Stomach	92
Colon	68
KUB	18
Urograms	10
Others	31
TOTAL	385
Total consultations, laboratory tests and roentgen procedures	967

Table I shows the various procedures ordered on a sample of 100 consecutive general examinations. In choosing the patients for this table, we considered "general examination patients" to be those who underwent at least three laboratory tests and one abdominal x-ray examination. The table is of interest from several standpoints.

In the first place, one should note the balance between the clinical, x-ray, and laboratory procedures. Then one should notice that, although no routine exists, the examinations italicized are requested in a large number of patients. These examinations may be considered as a survey to cover those fields where the clinical

[1] From the Carle Hospital Clinic, Urbana, Ill. Presented at the Thirty-fourth Annual Meeting of the Radiological Society of North America, San Francisco, Calif., Dec. 5–10, 1948.

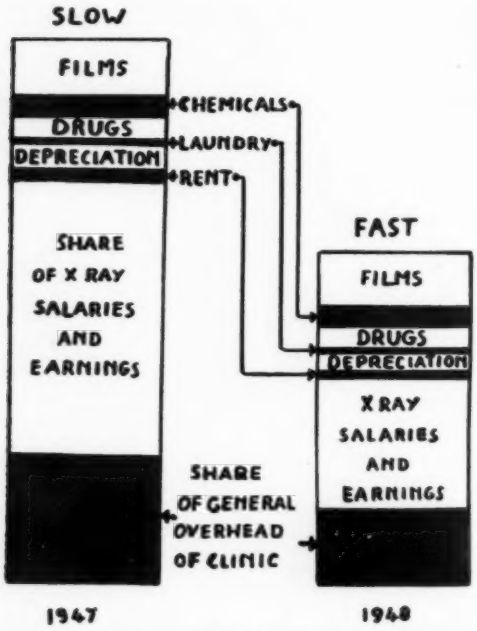

Fig. 1. Relative cost of a slow and of a fast visceral survey

search may give doubtful or misleading results. The radiological part of this survey usually includes the chest, esophagus, stomach, duodenum, upper small bowel, terminal ileum, colon, and gallbladder. Occasionally the kidneys are also explored with plain films or with intravenous urograms.

Considering the large number of roentgen examinations ordered in these 100 patients, one may feel compelled to ask whether all this work was really necessary. The answer is found in a review of the roentgen findings. These show that significant pathology was encountered 59 times in 52 patients, as follows: Chest, 8 times in 87 examinations; esophagus, stomach, duodenum, upper small bowel, 12 times in 92 examinations; terminal ileum and colon, 6 times in 68 examinations; gallbladder, 14 times in 79 examinations; KUB and intravenous urograms, 3 times in 28 examinations; other procedures, 16 times in 31 examinations. These results show that the accuracy and completeness of the roentgen visceral survey make it desirable to the patient and physician alike. In my opinion, this type of examination constitutes one of the most fruitful fields of radiology because radiologists can enjoy the most intimate co-operation with the whole staff of the diagnostic center.

General examinations are expensive, since they require highly trained medical personnel. This is especially true of the radiological visceral survey, where salaries or earnings constitute the largest portion of the cost to the patient (Fig. I). The cost of such examinations, however, is not exorbitant, and it can be held within very reasonable limits if the diagnostic center handles a sufficient number of patients without interference among the various departments. Since the larger the number of patients the less the cost per patient, speed becomes of importance in the economical conduct of a diagnostic center. It should be understood that by "speed" we do not mean short-cutting the actual examinations but rather the elimination of delay between examinations and the waiting on the part of the patient and of the doctors.

The radiological section of a diagnostic center is a very important part of the organization, inasmuch as a great deal of the patient's time is spent there. This requires a particular type of department where, without sacrifice of accuracy, the emphasis is again on speed to save cost to the patient.

The floor plan of our radiological section is laid out along conventional lines, with one radiographic and one fluoroscopic room on either side of the processing room. There are, however, two dressing rooms on the radiographic side and three dressing rooms on the fluoroscopic side equipped with toilets, making for easy circulation of patients. Recently we have also acquired the use of a small room where injections can be made for intravenous urograms. This avoids the immobilization of radiographic equipment during the injection and the subsequent waiting.

I believe that such a department equipped with two 500-ma. units with ro-

tating anode tubes, staffed by four technicians and a radiologist, is almost ideal for a diagnostic center staffed by about thirty physicians. However, in 1947, we were hard pressed to perform some 18,000 radiographic and 3,000 fluoroscopic examinations. In retrospect, we can see that the reason for this lay in the fact that visceral survey patients were seen several times on several successive days, thus wasting precious time and motion. This condition could not be changed then because of the preparation employed for the various roentgen examinations.

Up to January 1948, we used the following preparations:

Stomach: No food or drink for eight hours.

Gallbladder: Take dye at 8:00 P.M. No dinner. Report following morning after as many enemas as necessary to clear bowel. No breakfast.

Colon: Take two ounces of castor oil at 8:00 P.M. No dinner. Report the following morning after as many enemas as necessary to clear bowels. No breakfast.

Intravenous Urograms, Kidneys, Ureters, Bladder: No water or food after 12:00 noon. Two ounces of castor oil at 8:00 P.M. Report following morning.

This set of preparations gave excellent results, and I understand that it is used by many institutions; but a visceral survey conducted with these preparations necessitated at least three days, during which the patient was required to fast and to come to the clinic. This made four days the minimum time for conducting a general examination.

In January 1948, two patients made the mistake of taking 2 ounces of castor oil about one hour after the gallbladder dye. Much to our surprise, their gallbladders were unusually well visualized and the intestines were practically free of disturbing shadows. The following ten patients were then requested to take the gallbaldder dye at 3:00 P.M., no dinner, 2 ounces of castor oil at 8:00 P.M., and report on the following morning without breakfast. Their films were equally satisfactory, and since that time we have followed this procedure in all our patients. At the writing of this paper, September 1948, 1,843 patients have been examined in this fashion. This preparation allows the study of the gallbladder, the kidneys, intravenous urogram, stomach, colon, all at one session; this saves a great deal of time, allows a steady flow through the department, and, in my opinion, has improved the quality of our work.

The examination of the gallbladder is done in the radiographic room. This organ is examined with the patient prone, in a supine-oblique position, and upright. This gives multiple checks and eliminates shadows which are not within the gallbladder itself. The emptying of the gallbladder is not followed, on the assumption that a full gallbladder must have been emptied first. The upright position is especially useful for layering stones and the detection of gallbladder papillomata.

A KUB, an intravenous urogram (stereo films), or a chest examination may be done next, along with examination of the spine, skull, sinuses, and whatever other radiographic work may have been requested in the particular case. The patient is then transferred to the fluoroscopic room, where the colon is examined first, with an attempt to fill the terminal ileum. I may say that we use routinely the over-exposure technic for colon films. This allows detection of polyps without the lengthy and cumbersome air-contrast technic. The patient is then placed in one of the three toilets, where he empties the bowel, and is given a glass of barium with instructions to "drink all but one swallow." Another patient is brought in, his colon is examined, and he is placed in his toilet with the same instructions. A third patient follows. After the examination of the colon of the third patient, the first patient is brought back. At this time it will be found that the patient is relaxed, the colon is empty, and that the cap, the whole duodenal loop, and the upper small bowel are usually well visualized. After examination of the stomach and the duodenum, the patient is asked to take the swallow of barium which he had left in the glass, and the examination of

the esophagus usually completes the procedure. By examining three colons and three stomachs in such a fashion, one can complete each series of three patients in about twenty minutes. To allow for the radiographic work which precedes the fluoroscopic study, patients are expected to spend about forty-five minutes in the x-ray department. Under the old procedure, patients visited the x-ray department three times for a total time of about one hour and a half. Since the time spent in actual work is the same in both cases, it can be seen that the new system eliminates the time previously wasted undressing, dressing, waiting, emptying the bowel, and relaxing the pyloric sphincter during fluoroscopy, as well as the large amount of time between injection and films in the intravenous urography. It is hardly necessary to point out that forty-five minutes are not sufficient for some difficult patients and that these cases receive the necessary attention without regard to the scheduled time.

For the average case, however, forty-five minutes is all we need. This leaves ample time for other clinical and laboratory work, so that it is now entirely possible for a patient to come for his first visit one day, start his laboratory and dental examinations, return the next day for consultations, laboratory, and x-ray procedures, and obtain his final report from the physician in charge in the afternoon. A general examination can thus be completed in one and a half days instead of the four days required under the old system.

The economic implications of the changed procedure are of interest. The graphs in Figure I represent the expense of a fast and of a slow roentgen visceral survey, showing the relative importance of the various items entering into the determination of cost. One can see that the new procedure, by cutting in half the time spent by patients in the radiological section, has halved the share of salaries and overhead to be charged against each survey. This has also doubled the capacity of the radiological section, making unnecessary the addition of new equipment or personnel.

An important reduction of cost to the patient cannot appear in our accounting. It consists of the time saved by the patient himself. This may mean a considerable saving in the case of a wage earner or may mean a lower number of expensive trips for the many who do not live in the immediate vicinity.

In conclusion, I would like to say that the obvious advantages of a general examination and of a radiological visceral survey can be made available to larger groups if all the components of a diagnostic center are geared for the greatest possible efficiency so that we can strive for a reduction of costs without impairing the quality of the work done.

SUMARIO

Rápida Exploración Radiológica de las Vísceras

La exploración radiológica de las vísceras forma parte del examen general, iniciándolo un médico, quien, al terminar el estudio, correlaciona los hallazgos con las observaciones clínicas y de laboratorio. Por virtud del costo y del tiempo exigido, la aplicación del procedimiento es forzosamente limitada, pero puede ofrecerse a grupos numerosos a menos costo en tiempo y dinero coordinando todas las partes componentes del centro de diagnóstico a fin de obtener la mayor eficiencia posible.

La exploración suele comprender el tórax, esófago, estómago, duodeno, porción superior del intestino delgado, porción terminal del ileon, colon, vesícula biliar, y de cuando en cuando los riñones.

Contando con una sección radiológica bien organizada, el examen en la mayoría de los casos exige cuarenta y cinco minutos,

dando así tiempo de sobra para otros estudios clínicos y de laboratorio, de modo que al enfermo le resulta posible venir un día para su primera visita e iniciar sus exámenes dentales y de laboratorio, volver al día siguiente para consultas y procedimientos de laboratorio y roentgenológicos, y recibir por la tarde su informe final del médico encargado. El examen general puede, pues, ser completado en día y medio.

DISCUSSION

S. F. Thomas, M.D. (Palo Alto, Calif.): Because of the present day tendencies for broader medical coverage for everyone, and the general medical consciousness of the public, it is necessary that we look inward and review our methods of examination. Dr. Gianturco's method of meeting this problem is not the usual one, because the tradition of one examination at a time is broken. Although this type of examination has been done before, it has not been correlated with the other examinations to which patients are subjected, nor has the cost factor been analyzed in such a clear-cut manner. Therefore, the relative importance of the roentgenologic visceral survey, as compared with other consultation and laboratory-examinations, is placed in the proper perspective.

There are one or two points which might bring a little more realism into the exhibition of this method; one of them is the rapidity with which the examination is done. It is stated that forty-five minutes is the over-all time for the patient to spend in the x-ray department. Unfortunately, the patients with whom I deal cannot empty their colons as rapidly as this would imply. Filming of the patient is done much more often in my routine. My experience has been that the time for four patients is nearer ninety minutes. However, other points concerning the relaxing of the pyloric sphincter and the speed-up of intravenous urography are well worth noting.

One's particular physical set-up, of course, modifies the execution of Dr. Gianturco's visceral survey. Another thing is the type of patient. We find it most useful in those people that come from out-of-town and for those that are asking for a "complete check-up," yet have no actual complaints. We now include a photoroentgen study of the chest. Films are cheap and mistakes are costly. Too often the history is unreliable and a second history on the same patient is often quite different from the first. Also, localization as to organs in the non-acute case, by even the best of internists, is usually unreliable. Our experience with this method of examination is not as wide as Dr. Gianturco's, but we have used it long enough to know that it is a definite step ahead, and familiarity with the handling of patients in such a manner should be in the armamentarium of every radiologist, especially one who is working with a diagnostic team.

There is one technical procedure that Dr. Gianturco uses which should be critically attacked, and that is the attempted detection of polyps by means of over-exposed films of the filled colon. This is not only unsatisfactory, but unreliable, and should be discarded, at least until further evolution. This should not, however, detract from this paper in any way, and one should keep in mind that we, as practitioners of medicine, must "step lively," or be swallowed by the gargantuan socialistic tendencies of our government today.

T. J. Wachowski, M.D. (Aurora, Ill.): I think that any consideration of this method of examination should be based on a consideration of who makes the examination. Certainly there are people who, using this type of examination, would miss many lesions, and they probably would overlook more than would be compensated for by the saving in time. Having known Cesare for many years, I know that he would not do anything that would minimize the accuracy of his examination. I refer particularly to the over-exposure films of the thin barium mixture in the colon. He has found polyps that, I am certain, I would have looked for long and hard with any other method.

Dr. Gianturco (*closing*): I would like to thank Dr. Thomas and Dr. Wachowski for their remarks. I will try to answer the comments about the speed of examination and about the accuracy of colon studies with this method.

As far as speed is concerned, it is obvious that, although this is important from an economic standpoint, it should not be the primary aim of those who conduct radiological visceral surveys. Speed varies with the individual workers, and we all agree that it is less important than accuracy. The purpose of this paper is to show that many roentgen examinations can be combined and done well in one session. How fast the work is done depends entirely on the individual worker.

As far as the colon examination is concerned, I should have explained more thoroughly the "over-exposure" or high-voltage technic. This consists of exposing colon films with a voltage high enough to penetrate the barium and show polyps as translucent shadows, just as cholesterol stones appear in the opacified gallbladder. This technic was described in 1937 in the *Illinois Medical Journal* and I have used it since then with very satisfactory results. Its accuracy is of a high order and, since it can be used as a routine, it simplifies colon work a great deal.

An Improved X-Ray Phototimer[1]

PAUL C. HODGES, M.D., R. TABER JENKINS, Sc.B.,[2] and S. F. WILLIAMS, COMDR. (MC) U.S.N.[3]

IN THE FIRST x-ray phototimers, which were developed in this laboratory (University of Chicago) approximately six years ago, Morgan (1) employed a hot cathode thyratron (RCA 2051) as the trigger and connected its grid to the 9th dynode of the multiplier phototube (931). He was forced to abandon this arrangement, however, because of relatively poor internal insulation in the dynodes of the phototubes available at that time and to employ instead as the control electrode the better insulated anode. The output of this anode fed the control grid of a pentode (6J7) and thus an amplified voltage of the desired sign was supplied to the grid of a cold cathode trigger tube (1C21). Now that better insulated phototubes have become available (1P21 with mica-filled base), it is possible to revert to the 9th dynode as the control electrode.

Recently, aided by the expert advice and assistance of Professor Robert Moon and Mr. Karl Norris of our Institute of Radiobiology and Biophysics, we have designed new phototimers to replace those long used at the University of Chicago (2). The new sets differ from the old ones in the following respects:

1. The 9th dynode of the multiplier phototube rather than the anode is used as the output electrode, thus eliminating the amplifier and polarity inverter (6J7).

2. A hot cathode thyratron (2D21) is substituted for the cold cathode tube (1C21).

3. A precisely stabilized two-stage inverse feed-back high-voltage supply replaces the old supply in which stabilization depended on an OA4G in the primary circuit of the high-voltage transformer.

4. A resistor has been introduced in series with the metering condenser to compensate for the inherent lag in the opening time of the x-ray contactor.

5. The kv. compensating circuit has been eliminated because clinical experience has shown that when we employ multiple stops and multiple potentiometers for each stop the necessary voltage range for each combination of stop and potentiometer is so small that kv. compensation is not required.

6. The impedance and the shielding of critical circuits within the chassis and particularly in the detector cable have been improved, with resulting increased immunity to humidity and to high frequency transients.

THEORY OF CIRCUIT

Figure 1 is a simplified schematic diagram of the improved circuits. Section I is a filtered 105-volt d.c. source in which the negative pole is grounded. Section II is a filtered stabilized high-voltage d.c. source capable of precise regulation over a range of 300 volts (from 700 to 1,000 volts). Section III is the detector and trigger tube assembly.

Section I: When contacts 1A close, point W of the circuit receives filtered d.c. that is positive to ground and has a voltage maintained at 105 volts by the regulator tube VR105.

Section II: The positive side of the filtered high-voltage supply is at P and the negative side at N. The voltage between P and N is fixed except for fluctuation in the voltage of the line that supplies the transformer and of the load that is drawn from it. The voltage between X and Y

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[2] On loan to the University of Chicago from the Committee on Atomic Casualties of the National Research Council. Supported by the United States Atomic Energy Commission.
[3] Research Fellow, University of Chicago, for the year 1948–49.
The opinions expressed in this article are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

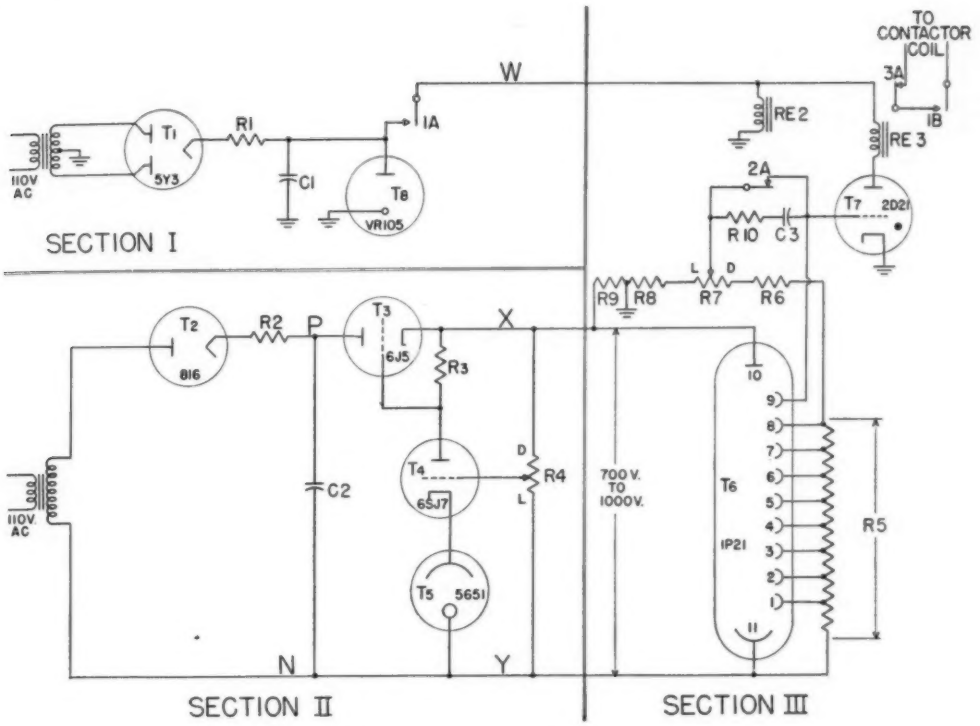

Fig. 1. Schematic diagram of phototimer circuit.

rises and falls as the sliding contact of the potentiometer R_4 is moved toward L (for light) or toward D (for dark), respectively, but is stabilized against fluctuation of the line or the load. Regulation and stabilization are accomplished by a two-stage inverse feed-back circuit.

The voltage between X and Y is determined by the current that is passed by T_3, which in turn is controlled by the negative bias on the grid of that tube. The voltage regulator tube (T_5) is shown schematically in Figure 1 as a single tube but actually (Fig. 2) consists of two 5651 tubes in series. These tubes maintain the cathode of T_4 at about 160 volts positive relative to Y. When the contact of the potentiometer (R_4) is moved toward L, the negative bias on the grid of T_4 is increased and less current passes through that tube. This in turn decreases the negative bias on the grid of T_3, increasing the flow through that tube and thus increasing the voltage between X and Y. In practice, potentiometer R_4 is used to adapt the set to phototubes of varying sensitivity.

Automatic stabilization follows the same pattern. If the positive voltage at X starts to rise in response to a rise in line voltage, the negative bias on T_4 falls, that on T_3 rises, and the consequent fall in current through T_3 returns the voltage between X and Y to the value that was determined by the setting of potentiometer R_4.

Section III: When the voltage between X and Y is supplied to electrodes Nos. 10 and 11 of the phototube T_6 and light falls on the photocathode (No. 11) the electrons which are emitted by the photocathode are pulled toward dynode No. 1, since that dynode is positive relative to No. 11. When they strike the secondary emitting surface of dynode No. 1, additional electrons are emitted from it. These in turn are pulled to the even more

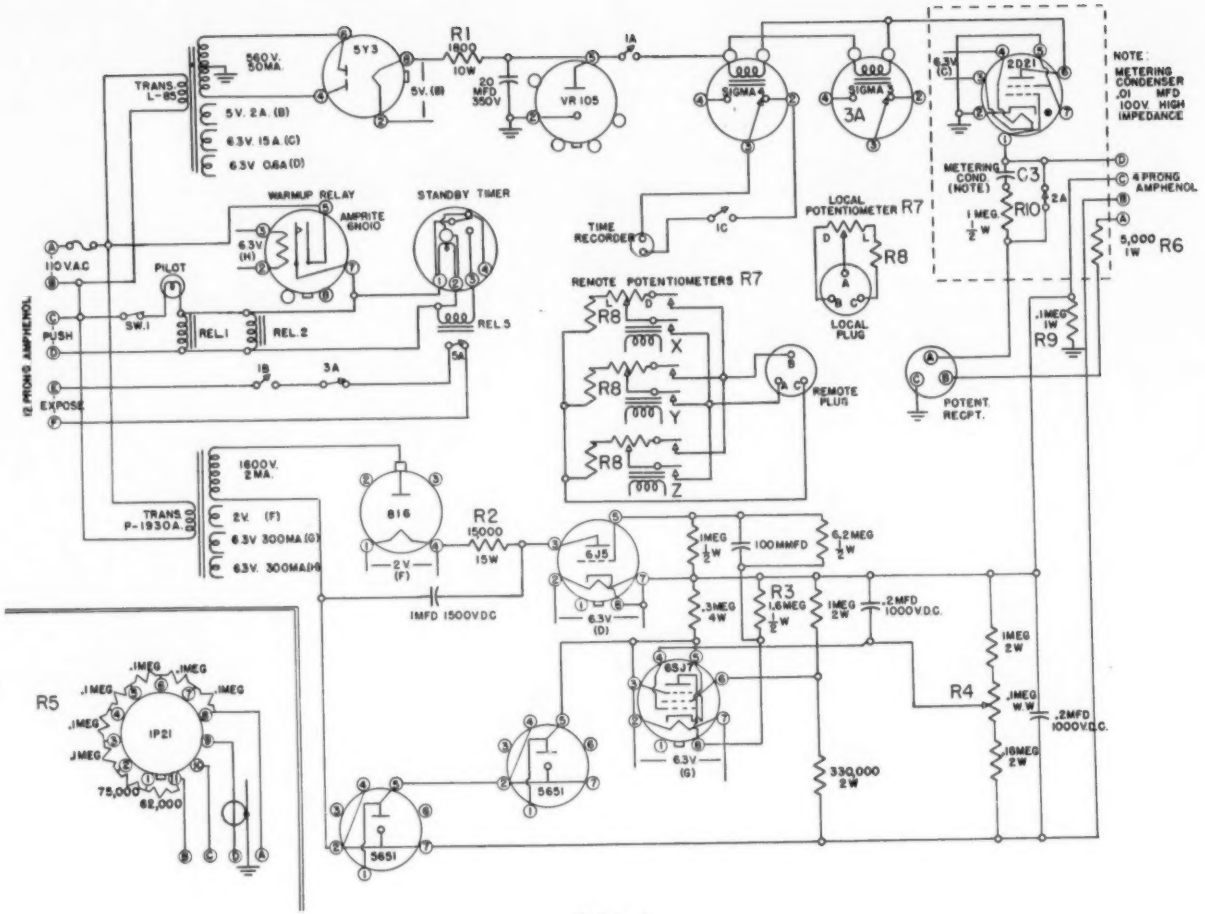

Figure 2
(See opposite page for legend)

positive dynode No. 2, the process being repeated until the anode (No. 10) is reached. Since each dynode emits approximately four times as many electrons as it receives, each would become deficient in electrons if it were not for an electron flow from Y through the resistor network R_5, which maintains equilibrium.

Before the x-ray exposure starts, dynode No. 9 like the others is connected to Y, the circuit being made over the normally closed contacts (2A), part of R_7, all of R_6 and R_5. At the start of the exposure, however, the contacts 2A open, and the grid of the trigger tube and dynode No. 9 are left "floating" on C_3 without a direct electrical connection to Y. Now as dynode No. 9 becomes relatively positive by delivering to the anode No. 10 four times as many electrons as it received from dynode No. 8, the deficiency is made up by a flow of electrons from C_3 through R_{10}. As a result of this flow, a positive voltage V_R appears across R_{10} and another V_C builds up across C_3. The total voltage, which is the sum of these, is designated V_F.

Relay No. 3 is energized only when T_7 triggers, and this happens only when the bias on the grid of that tube falls below -3 volts relative to its cathode. The original bias is established by the voltage drop between ground and the sliding contact of R_7. The bias grows greater as that contact is moved toward D and smaller as it is moved toward L, and it is by varying this bias that one adjusts the sensitivity of the phototimer so that films made with it will have the desired degree of blackness. Moving the contact of R_7 toward L makes films lighter; toward D, darker. The condenser C_3 is made with a dielectric of extremely high impedance, so that after contacts 2A open, the bias of T_7 is reduced only by the flow of electrons to dynode No. 9. This flow, which continues throughout the x-ray exposure, produces the positive voltage V_F across the C_3R_{10} combination.

Details of Circuit: Figure 2 is a detailed circuit diagram of the phototimer. The two 5651 tubes are represented in Figure 1 as a single tube, T_5. The 12-prong amphenol connector at the left of the diagram connects the phototimer chassis to the control stand of the x-ray machine. Contacts A and B supply 110 volts a.c. to the chassis. Contacts C and D connect to the push-button that is used to initiate the x-ray exposure. Contacts E and F are connected to the control stand circuits so that when they are shorted together in the phototimer chassis an x-ray exposure occurs.

The 4-prong amphenol connector shown at the right connects the phototimer chassis to the phototube detector that is shown in a box in the lower left-hand

Fig. 2. Detailed circuit diagram of phototimer
(For additional information, see text)

The 0.1 megohm resistors of the R_5 network are Ohmite "Little Devil," 1/2 watt. R_1 is an 1,800-ohm 10-watt resistor; R_2 a 15,000-ohm, 15-watt resistor, etc.

In the detector cable shown in the box at the left of the diagram, the signal lead of kinked phosphor bronze is insulated with polyethylene and is independently shielded. A flexible metal tube covered with waterproof plastic encloses all four leads.

Transformers L-85 and P-1930A are supplied by the Halldorson Co. of Chicago.

The 1 mfd., 1,500-v., d.-c. oil-filled filter condenser is by Aerovox of New Bedford, Mass. It is important that it be of the type in which both leads are insulated from the metal case.

The fixed resistors of R_4 should be of the "Gold Band" type with a tolerance of ± 5 per cent.

The broken line rectangle at the upper right represents a completely shielded metal box inside the chassis. The contacts of 2A, which lie within this box, are insulated with polystyrene and are held closed by a polystyrene rod that is attached to the armature of relay No. 2 and passes through a small hole in the box.

Ceramic sockets are used for tubes 5651 and 2D21.

Relays 1, 2, 5, X, Y, and Z operate on 110 volts a.c. and are of the type 550 manufactured by the Guardian Electric Manufacturing Co., Chicago.

The 3-prong, 4-prong, and 12-prong connectors are of the A.N. type and are obtained from the American Phenolic Corporation of Chicago.

Local potentiometer R_7 is a 100,000-ohm, 2-watt wire wound micropot supplied by the G. W. Borg Corporation of Delavan, Wisconsin.

Remote potentiometer R_7 is wire wound, 100,000-ohm, 7-watt. R_8 is a fixed 1/2-watt resistor of 5,000 ohms resistance.

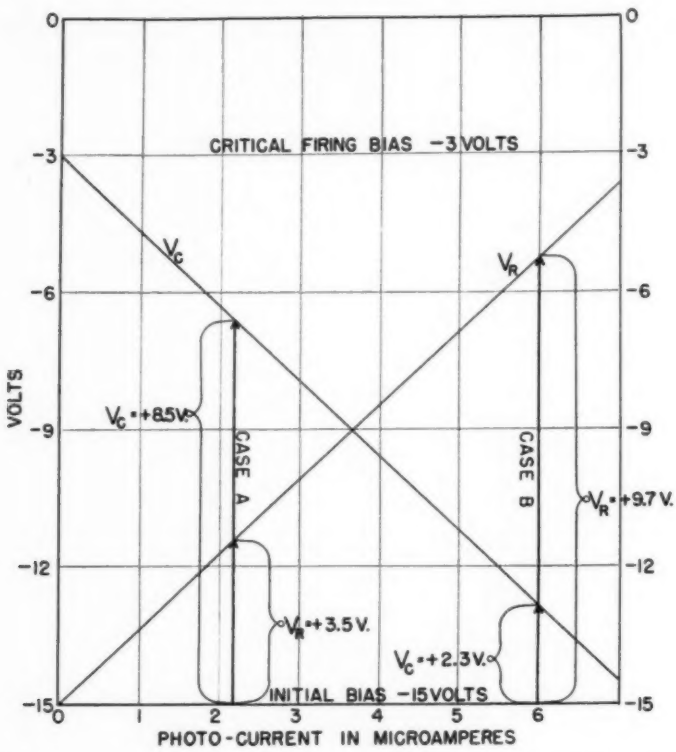

Fig. 3. Distribution of voltage across metering condenser and lag compensating resistor (R_{10}) at the instant of firing of the trigger tube (2D21)

When the 2D21 has a plate voltage supply of 105 volts, its critical firing bias is −3 volts. The initial grid bias is determined by the position of the slider of R_7 relative to ground, and in the figure this value is given as −15 volts. As electrons flow from the metering condenser C_2 to dynode No. 9 of the phototube, the grid of 2D21 becomes less negative, and when the negative voltage falls to the critical value of −3 volts, 2D21 fires and the x-ray exposure is terminated.

The voltage change V_F which reduces grid bias to −3 volts is made up of the positive voltage V_R, which appears across R_{10} as soon as the phototube current i begins to flow, plus the positive voltage V_C on condenser No. 3 which builds up linearly with time. It is the time required for V_C to develop to a critical value that determines the length of the X-ray exposure.

In example A the part being rayed is thick, the photocurrent is only 2.2 microamperes, and V_R only +3.5 volts. But a change of 12 volts is required to reduce grid bias to −3 volts so that the exposure continues until V_C rises to +8.5 volts.

In example B the part being rayed is thin, and photocurrent rises to 6 microamperes. Now V_R becomes +9.7 volts so that the exposure continues only during the short time required for V_C to rise to +2.3 volts.

corner of the diagram. In the connecting cable the signal lead which connects to dynode No. 9 is provided with polyethylene insulation and is independently shielded.

The heater coil of the warm-up relay (Amprite No. 6N010) receives 6.3 volts a.c. as soon as the chassis is energized, and approximately ten seconds later its normally open contacts (5 and 7) close. The closing of these contacts lights the pilot lamp and connects one side of the 110 a.c. supply to the coil of relays No. 1 and No. 2. Now when contacts C and D of the 12-prong amphenol connector are shorted together by the exposing switch in the control stand of the x-ray machine, relays No. 1 and No. 2 are energized. The three N.O. contacts 1A, 1B, and 1C close, and the N.C. contacts 2A open.

The stand-by timer (R. W. Cramer, type T.E.C. Serial 49502A) is set for an exposure time deemed safe for the particu-

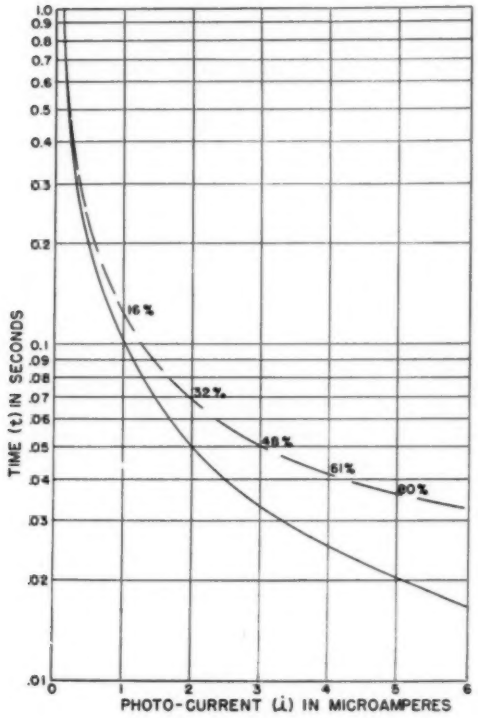

Fig. 4. Improvement of phototimer operation by addition of lag-compensating resistor (R_{10})

The solid curve is a plot of Equation 2

$$t = V_F C/i$$

where
$C = 10^{-8}$ farads,
$V_F = 10$ volts.

It is also a plot of Equation 9 when the values of R and C are adjusted so that $RC = L$.
It illustrates the response of a compensated instrument.
The broken curve is a plot of Equation 3

$$t = (V_F C/i) + L$$

where
$C = 10^{-8}$ farads,
$V_F = 10$ volts,
$L = 1.6 \times 10^{-2}$ seconds.

It illustrates the response of a phototimer when R_{10} is not in the circuit to compensate for the lag of the x-ray contactor.

In this figure it is assumed that sensitivity has been adjusted so that the uncompensated timer provides exposures of satisfactory blackness when parts are thick and the photocurrents, therefore, are small. For slightly thinner parts (photocurrent = 1 microampere) the addition of contactor lag to the response of the uncompensated timer causes an exposure that is only 16 per cent longer than optimum, but when the part is so thin that the photocurrent rises to 5 microamperes, the presence of lag results in an 80 per cent over-exposure. At 2 microamperes lag adds 32 per cent to optimum exposure time; at 3 microamperes, 48 per cent; and at 4 microamperes, 61 per cent.

lar x-ray tube and load that are being used. The motor of the stand-by timer starts as soon as the exposure begins and, if for any reason the time called for by the phototimer exceeds the safe limit for the tube, the N.O. contacts No. 1 and No. 3 close, energizing the coil of relay No. 5, opening its N.C. contacts 5A, and thus terminating the exposure.

Sigma 3 (Sigma Instrument Co., Boston, Mass., No. 1911) is the d.c. relay No. 3 of Figure 1. It has a single pair of normally

closed contacts, 3A. When the 2D21 fires and Sigma 3 is energized, contacts 3A open, thereby terminating the x-ray exposure.

Sigma 4, the 2-prong amphenol connector labeled "time recorder," and the relay contacts 1C constitute a circuit that is used only for shop testing to determine the length of exposures that are called for by the phototimer. When a suitable time recorder (Standard Electric Time Co., Springfield, Mass., Type S.1) is plugged into the 2-prong amphenol connector, it begins recording as soon as contacts 1C close at the start of the x-ray exposure and stops when the 2D21 fires and the contacts No. 2 and No. 3 of Sigma 4 open.

For some applications, such as sets used exclusively for "spot filming," the local potentiometer R_7 is plugged into the potentiometer receptacle. For general radiography, however, one plugs in a bank of remote potentiometers using one at a time, depending on the particular potentiometer relay that is energized. The diagram shows a bank of three such remote potentiometers and three potentiometer relays designated X, Y, and Z.

RÉSUMÉ OF OPERATION

After the set has warmed up, the closing of the x-ray exposure switch energizes relays No. 1 and No. 2, causing the three N.O. contacts 1A, 1B, and 1C to close and the N.C. contacts 2A to open. The closing of 1A puts the 2D21 in circuit, 1B starts the x-ray exposure, thus causing the detector screen to glow and emit photons that fall on the photocathode No. 11 of the 1P21, and, if a time recorder is being used, the closing of 1C starts it. The opening of contacts 2A unshorts the metering condenser C_3.

With the start of the x-ray exposure, a positive voltage appears across R_{10} and another builds up across C_3, and when the sum of these (V_F) becomes great enough to reduce the bias of the grid of 2D21 to less than -3 volts, that tube triggers (see Fig. 3).

When 2D21 becomes conducting, relay No. 3 is energized, the normally closed contacts 3A open, and the x-ray exposure is terminated.

If a time recorder is in circuit, the triggering of 2D21 also opens the normally closed contacts No. 2 and No. 3 of relay No. 4, thereby stopping the recorder.

LAG COMPENSATOR

Ideally the exposure time (t) called for by an x-ray phototimer should be inversely proportional to the photocurrent (i) that is produced by light from the detector screen, which in turn is proportional to the radiation that passes through the patient's body and impinges on the screen. This relationship may be expressed as an equation:

$$t = K/i \qquad (1)$$

where

t = exposure time in seconds,
i = phototube current in amperes assumed to be constant for a given set of conditions,
K = a constant.

In Morgan's original phototimers K was equal to the product of the capacity of the metering condenser in farads, designated C, and the voltage on the metering condenser required to fire the trigger tube, designated V_F. Substituting these values for K, we have as the formula for ideal operation:

$$t = V_F C/i \qquad (2)$$

Actually, however, the heavy contactors commonly used to break the current to x-ray transformers do not terminate the exposure until approximately 1/60 of a second after the current to their coils has been broken. This delay or lag may be designated L and, when it is taken into consideration, the practical equation becomes:

$$t = (V_F C/i) + L \qquad (3)$$

where L = contactor lag in seconds.

When L is small compared with $V_F C/i$, the practical equation (3) approximates the ideal equation (2), but when t is very short L does become significant. Under such circumstances, when the sensitivity

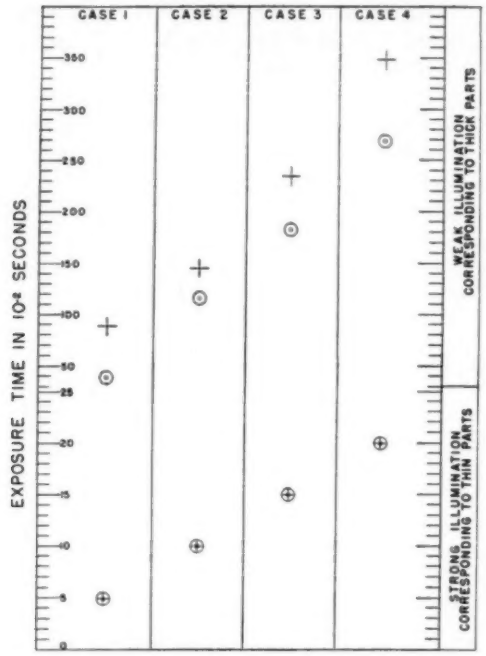

Fig. 5. Experimental demonstration of the action of the lag-compensating resistor R_{10}

Under actual operating conditions, for example the spot-filming of the gastro-intestinal tract, the light that affects the detector of the phototimer comes from a fluorescent screen. That light is strong when the x-rays that incite it pass through transparent portions of the patient's body, such as the barium-filled esophagus flanked by air-filled lung, or is weak when the radiation passes obliquely through the trunk in order to demonstrate the pyloric antrum. In the absence of R_{10} a timer adjusted to give optimum density for the esophagus and gastric fundus will underexpose heavy parts or, when adjusted for normal exposures of heavy parts, will overexpose light ones.

In the experiment illustrated here a variable light source has been substituted for the light from a fluorescent screen. The symbols used in the figure have the following meaning:

$\odot$ represents a reading made with R_{10} reduced to 0

$+$ represents a reading made when the resistance of R_{10} is 10^6 ohms (1 megohm)

$\oplus$ indicates that a $\odot$ reading and a $+$ reading coincide.

Case 1: With R_{10} at 10^6 ohms and with the light source strong, the sensitivity regulator of the timer (potentiometer R_7) was adjusted until the exposure time called for was 5×10^{-2} seconds. Now when the light was dimmed and another exposure was initiated, it was found that the timer called for an exposure of 85×10^{-2} seconds. With R_{10} at 0 and the light source strong, sensitivity was readjusted until the exposure time again was 5×10^{-2} seconds. Now when the light was dimmed, it was found that the timer called for an exposure of only 38×10^{-2} seconds.

Here we see a compensated timer (one in which $R_{10} = 10^6$ ohms) giving an adequately long exposure for thick parts even though it has been calibrated on thin parts, while an uncompensated timer (one in which the resistance of $R_{10} = 0$) underexposes thick parts if it has been calibrated for thin parts.

Case 2: In Case 2, when the set had been calibrated to give exposures 10×10^{-2} with strong illumination, weak illumination called for an exposure of 145×10^{-2} when $R_{10} = 10^6$ ohms but only 115×10^{-2} when $R_{10} = 0$.

Case 3: In Case 3, strong light exposures are 15×10^{-2} seconds long, while weak light exposures are 240×10^{-2} and 185×10^{-2}, respectively.

Case 4: In Case 4, the three values are 20×10^{-2}, 350×10^{-2}, and 270×10^{-2}.

In the converse situation (not illustrated here), if sensitivity is adjusted so that with weak illumination exposures are the same with R_{10} at 0 and R_{10} at 10^6 ohms, then it will be found that under strong illumination the timer will call for a relatively long exposure when $R_{10} = 0$ but will reduce the exposure to the desired degree of shortness when $R_{10} = 10^6$ ohms.

is adjusted for the long exposures required by thick parts, it will be found that the short exposures called for by very thin parts are not short enough and the resulting films are more or less over-exposed.

R_{10} has been added to the circuit of the new timers to improve this situation and make actual operation more nearly like that called for by the ideal equation (2).

In the presence of the lag compensating

resistor R_{10}, the voltage V_F that is required to fire the trigger tube is made up of V_C, which is the voltage that builds up on the metering condenser, plus V_R, which is the voltage that appears across R_{10} as soon as the photocurrent i begins to flow.

$$V_F = V_C + V_R \tag{4}$$

A constant current, i, flowing for a period of time, t, will develop a voltage V_C across a condenser of capacity C in accordance with:

$$V_C = it/C \tag{5}$$

By Ohm's law the voltage V_R that appears across a resistor R as a result of a current flow, i, will be:

$$V_R = iR \tag{6}$$

When these values of V_C and V_R are substituted in equation 4, we have:

$$V_F = iR + (it/C) \tag{7}$$

Solving for t, there results:

$$t = (V_F C/i) - RC \tag{8}$$

When L is added to account for the lag in the contactor, we obtain:

$$t = (V_F C/i) - RC + L \tag{9}$$

Now if we use a metering condenser of such a capacity, C, and a lag resistor of such resistance, R, that the product RC yields a numerical value identical to that of the contactor lag L, then these three terms R, C, and L cancel out of equation 9, leaving:

$$t = V_F C/i \tag{2}$$

which, as we have seen, is the formula for the operation of an ideal system in which there is no contactor lag.

We have standardized on a metering condenser having a capacity of 10^{-8} farads (John E. Fast, Chicago, polystyrene-insulated, 100 volts, d.c., 0.01 mfd., no. A7878HA) and the lag in contactors available to us is approximately 1/60 seconds or 1.6×10^{-2} seconds. Theoretically, therefore, the lag resistor R_{10} should have a resistance of 1.6×10^6 in order to satisfy Equation 10:

$$\underset{(R)}{1.6 \times 10^6} \times \underset{(C)}{10^{-8}} = \underset{(L)}{1.6 \times 10^{-2}} \tag{10}$$

Actually, however, we prefer the clinical results when a somewhat smaller lag resistor is used. For some applications R_{10} is a potentiometer whose resistance can be varied from 2×10^6 ohms to 0; and for others a fixed resistance of 10^6 ohms is used.

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SUMARIO

Roentgeno-Foto-Cronógrafo Perfeccionado

El nuevo roentgeno-foto-cronógrafo aquí descrito discrepa de su predecesor en los siguientes puntos:

(1) Como electrodo de salida se emplea el 9° dínodo del fototubo multiplicador en vez del ánodo, eliminando así el ampliador y el invertidor de la polaridad (6J7).

(2) En vez del tubo frío del cátodo (1C21), utilízase un tiratrón caliente del cátodo (2D21).

(3) Un foco de alto voltaje de contra-alimentación inversa en dos fases estabilizado con toda precisión suplanta el antiguo foco en el que la estabilización dependía de un OA4G en el circuito primario del transformador de alto voltaje.

(4) Se ha introducido un resistidor en serie con el condensador-medidor para compensar el retardo inherente en el tiempo de apertura del contactor roentgenológico.

(5) Se ha eliminado el circuito compensador de kv. por haber demostrado la observación clínica que, al emplear potenciómetros múltiples para cada parada, es tan pequeño el cambio de voltaje necesario para cada combinación de parada y potenciómetro que no se necesita compensación de kv.

(6) Se han perfeccionado la impedancia y la protección de los circuitos básicos dentro del portaplacas y en particular en el cable del detector, obteniéndose así más garantías contra la humedad y las variaciones de alta frecuencia.

Hidradenitis Suppurativa Axillaris

An Analysis of 54 Cases Treated with Roentgen Rays[1]

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HIDRADENITIS suppurativa is an inflammatory disease which has a predilection for certain regions of the body, such as the axillae, groins, breasts, and perianal area. It occurs more frequently than is generally recognized, and is often diagnosed as abscess, furunculosis, or carbuncle. By far the most common site is the axilla. It is with hidradenitis suppurativa axillaris that this report is mainly concerned. It is based on a series of 58 cases seen in the past ten years.

Almost a century ago this entity was first recognized by Verneuil (1), a French surgeon, who clinically associated the abscesses with the apocrine sweat glands. In contradistinction to the eccrine or ordinary sweat glands, which are derived from the epidermis and are distributed over almost the entire surface of the body, the apocrine glands originate from the hair follicles which develop with puberty and are commonly found in the skin of the axillae, mammae, genitalia, perianal and inguinal regions.

Histologically, the apocrine sweat glands are larger than the ordinary eccrine glands. They are situated in the folds of the skin and are therefore prone to infection because of the friction to which they are subjected. The infection tends to assume a chronic form, due to the tortuosity of the excretory ducts of these glands, which impedes drainage.

Although the exact etiology of hidradenitis is obscure, it is due, in most instances, to external causes, such as local inflammatory processes, irritation by depilatories or shaving, the friction of tight clothing, and excessive sweating. It is more common in the warm than in the cold months of the year. According to Tachau (2), a small percentage of the cases (10 per cent) represent a complication of a local or generalized inflammatory dermatosis, such as eczema, contact dermatitis, epidermatophytosis, erythrasma, or arsphenamine dermatitis.

Hidradenitis suppurativa is associated with a variety of bacteria, probably the most common offender being the *Staphylococcus pyogenes aureus* (possibly the *albus* or *citreus* as well). Pathologically, the apocrine sweat glands are involved in an inflammatory reaction which progresses to suppuration. As in all infections, there is a polymorphonuclear and lymphocytic infiltrate which tends to progress to a chronic stage. By contiguity other glands in the same location become involved, so that in a single region one may observe two or more areas of infection in various stages of the inflammatory process. The infection spreads from the primary focus by way of the lymphatics and tissue spaces in the skin and subcutaneous tissues.

In the early stages, a small hard mass is seen, resembling an ordinary boil or furuncle, which goes on to suppuration. The furuncle either opens spontaneously or is lanced, when only a small drop of pus is expressed, leaving behind a hard marble-like nodule. In favorable cases this residual mass slowly goes on to resolution. More commonly, however, the process spreads to one or more areas near the primary focus (Fig. 1). These new abscesses pass through the same stages of inflammation as the original lesion. In addition to suppuration, in the more advanced cases, there are undermining, burrowing, sinus formation, and cord-like thickenings in the axilla.

The process is associated with pain and tenderness, with or without a low-grade elevation of temperature. The arm is held

[1] Accepted for publication in November 1948.

away from the body to avoid friction. The more acute the local inflammatory process, the more severe the pain and the greater the tendency to hold the arm in slight abduction. An acute lesion persists for several weeks, but the chronic forms may last for months or years. Macey (3) reports a case which persisted for five years in one axilla and a year and a half in the other. The longest duration among our cases was eleven months.

Fig. 1. Right hidradenitis suppurativa axillaris of three months duration. Patient received ten x-ray treatments, with complete recovery.

TREATMENT

All of our cases were treated with roentgen rays, with or without some minor surgery, such as lancing of the abscesses which showed suppuration and in which the pain was hyperacute. No other treatment was administered, except for sedation, as required. Most of our patients, before being referred for roentgen therapy, had been treated with wet compresses and incisions; some, in recent years, with chemotherapy. All of the referred cases were in an active stage when first seen by us, notwithstanding their previous care and treatment. It was for this reason that resort was had to irradiation.

Before the institution of roentgen therapy, the axilla is carefully shaved or the hair is closely cropped. With the arm elevated above the head, the axilla is irradiated with a 10 × 10-cm. cone at 50 cm. target-skin distance. One hundred to 200 r (measured in air) are administered, depending on the acuteness of the inflammation. In hyperacute cases only 100 r (in air) are given, the dosage being increased as the severity of the disease diminishes. In the chronic types, 150 to 200 r (in air) are delivered at one sitting. The other technical factors are 180 kv.p. and 0.5 mm. copper and 1.0 mm. aluminum filtration. The half-value layer is 0.9 mm. copper.

The axilla is thus irradiated three times a week for from five to ten treatments, or for a total of 1,000 to 1,200 r (in air). Even in chronic forms it is seldom necessary to exceed this total. This dosage is within the limits of safety and well under a skin erythema dose. Occasionally, there may be a temporary epilatory effect. If depilation does occur, the hair returns in from two to three months.

If both axillary regions are involved, each axilla is treated, as described above, on alternate days (Fig. 2). Supplementary treatment consists of conservative surgery in the form of punctiform incisions of the fluctuating abscesses and the application of dry dressings. It is well to avoid the use of adhesive plaster in the irradiated area, since it is inadvisable to subject skin to irradiation which is irritated by the zinc oxide adhesive. We usually recommend a home-made cloth pad to cover the axilla. This is held in place by twilled tape sewed to each corner and tied around the chest, arm, and shoulder. The pad may be sterilized by boiling, or a sterile pad of gauze may be interposed between it and the skin. Hot wet compresses tend to in-

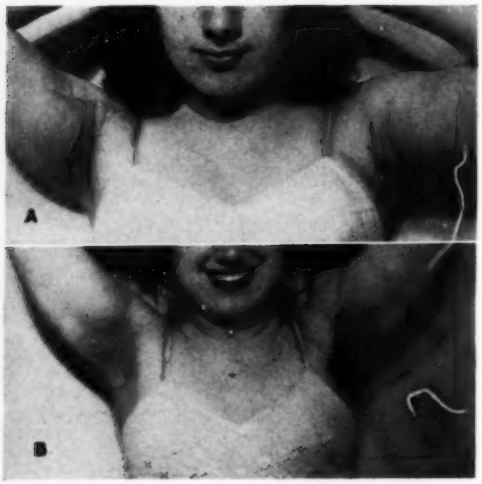

Fig. 2. A. Bilateral hidradenitis suppurativa of four and a half months duration.
B. Five weeks later. Condition cured after eight x-ray treatments to the left and six to the right axilla.

crease the pain and are therefore avoided.

Not infrequently, it may be too painful to raise the arm above the head, particularly in the hyperacute cases. It may then become necessary to irradiate the affected axilla through two portals of entry with the arm adducted. An anterior and a posterior axillary portal are then employed, being treated alternately.

Clinically, the rays effect a rapid reduction of pain and tenderness. The abscesses quickly become delimited. Either they are absorbed or, if they are broken down, suppuration and pointing are hastened. The surrounding residual induration disappears. In two or three treatments most of the pain is gone, particularly when the fluctuating nodules are evacuated of pus by lancing with a bistoury.

The action of the rays on inflammatory processes is upon the round-cell infiltrate, consisting mainly of polymorphonuclear leukocytes and lymphocytes, which are rapidly destroyed. This cellular destruction liberates the enzymes and antienzymes within the cellular walls which bathe the inflammatory process, thus neutralizing its toxins (4).

ANALYSIS OF CASES

In the past ten years, 58 cases of hidradenitis suppurativa axillaris were treated with roentgen rays. Not included in this report are 4 cases involving the genitals and inguinal regions, 2 in the perianal area, and 1 in the areola of a female breast, all of which responded favorably to x-rays.

Of the 58 cases involving the axilla, 54 were followed for at least three months after the last x-ray exposure. In our analysis only these cases will be considered. Each of the 54 cases responded well to roentgen therapy without any recurrence. In none was any extensive surgical procedure required, such as an excision of the apocrine gland-bearing area with subsequent skin grafting, as was necessary in the case described by Macey (3).

Twenty-five of our cases involved the right axilla and 20 the left axilla; in 9 the disease was bilateral. The cases were almost evenly divided between males and females—25 males and 29 females. The ages ranged from 15 to 38, the average being 24 years. It is evident that hidradenitis is a disease of adults in the late part of the second, the third, and the early part of the fourth decade. This is as would be expected, since the affected glands, namely, the apocrine glands of the epidermis, develop after puberty.

Eight patients in the series of 54 had a single abscess, which responded quickly to an average of three x-ray treatments. Among the remainder, 9, as stated above, had the disease in both axillae. Hence in 46 patients 55 axillary regions were treated. To cure each axilla an average of 7.8 treatments were given. This average number of treatments included the chronic and persistent cases, one of which had a duration of eleven months. The duration of the disease when these patients first presented themselves for treatment varied from two weeks to eleven months, the average being 1.4 months. None of the cases was complicated by diabetes mellitus.

SUMMARY AND CONCLUSIONS

Hidradenitis suppurativa axillaris is a

not uncommon disease in young adults. The infection involves the apocrine sweat glands of the axilla, and tends to become persistent and chronic. It responds favorably to high-voltage x-ray treatments. Roentgen therapy relieves the pain and aborts the disease, which otherwise may persist for months and years. Chronic cases respond rapidly, thus avoiding the possibility of extensive surgery. The earlier roentgen treatments are given in the course of the disease, the more rapid is the response and the fewer are the treatments necessary. Chronic cases require more exposures than those of short duration, but the end-result is good. There were no recurrences in the series of 54 cases reported.

Roentgen therapy is the most effective method of treating hidradenitis suppurativa axillaris, and is considered the treatment of choice (5).

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SUMARIO

Hidradenitis Supurativa Axilar: Análisis de 54 Casos Tratados con los Rayos X

La hidradenitis supurativa axilar es una enfermedad, no rara, de la juventud, caracterizada por infección, que tiende a volverse crónica, de las glándulas sudoríparas apocrinas. Durante un período de diez años 58 casos fueron tratados con la roentgen irradiación aplicada a la axila con un cono de 10 × 10 cm. (180 kv., filtración por 0.5 mm. de cobre más 1.0 mm. de aluminio, 50 cm. de distancia foco-piel, 0.9 mm. de cobre como capa de hemirreducción). Los casos más agudos recibieron 100 r (al aire) en cada tratamiento, aumentándose la dosis a medida que disminuía la gravedad de la afección. En los casos crónicos se administran 150 a 200 r (al aire) en una sesión. Los tratamientos se administran tres veces por semana y rara vez se excede de una dosis total de 1,000 a 1,200 r (al aire).

Mientras más pronto se administra la roentgenoterapia en la evolución de la dolencia, más rápida es la respuesta y menor el número de tratamientos necesarios. El dolor se alivia y se aborta la evolución. En 54 casos observados por lo menos tres meses, no hubo recurrencias.

La roentgenoterapia está considerada como el método más eficaz de tratamiento de esta enfermedad y como procedimiento de elección.

Unilateral Tuberculous Abscess of the Thoracic Spine with Roentgen Findings of a Dumb-Bell Neurofibroma[1]

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THERE IS NO DOUBT that tuberculous infection of the spine is protean both in appearance and course. The case to be reported here so closely resembled a spinal nerve neurofibroma roentgenologically that it seems worthy of record.

Rigler, Ude, and Hanson (1), in 1930, called attention to the typical changes produced by tuberculous abscess of the spine. They described the abscess as forming a soft-tissue shadow, spindle or fusiform in shape, symmetrical, and bilateral in extent, with a slight irregularity of its outer margins. They pointed out that the shadow of the abscess may be the first roentgen sign of tuberculosis, even preceding visible changes in the vertebral bodies.

The roentgen signs of spinal tuberculosis were the subject of a report by Doub and Badgley (2) in 1932, and the fact that little of any radiologic significance has been added since that time testifies to the completeness of their study. They found bilateral paravertebral abscess to be the most common complication (present in 84 per cent of their 100 cases) and the most definite single pathognomonic feature of tuberculosis of the spine.

A case of unilateral spinal tuberculous abscess was reported by Saenger (3) in 1947. In this case the extent of the abscess shadow was extensive enough to warrant a diagnosis of tuberculosis even though the lesion was unilateral.

Garland (4) and Brailsford (5) called attention to a valuable thoracic paravertebral landmark in the postero-mesial pleural line in 1943. This linear shadow, commonly seen to the left of the thoracic vertebral column, was shown by careful study to represent the postero-mesial aspect of the left lung. The shadow is seen only rarely on the right. Displacement of this linear shadow by a large, left-sided, unilateral tuberculous abscess was aptly described by Saenger in the report of his case (3).

The roentgen findings and the unique character of growth of dumb-bell neurofibromas are well known. These tumors arise from the posterior nerve roots, with a spinal portion within the vertebral canal and a larger external portion growing extrapleurally and paravertebrally. The two portions communicate by a narrow neck which passes through the intervertebral foramen. Dumb-bell tumors are nearly always located in the upper and, of course, the posterior mediastinum. The roentgen appearance in a typical case is highly characteristic. A rounded but sharply delineated shadow of soft-tissue density, varying considerably in size, projects to one side of the spine. There may be bony erosion of the adjacent rib margins or the vertebral end of the rib, along with enlargement of the intervertebral foramen. An increase of the intercostal rib space at the affected level occurs. This is believed to be due to the extrinsic pressure exerted by the expanding tumor and to elevation of the superior rib produced by its rotation.

Confusion of a tuberculous abscess with a spinal neurofibroma on roentgen study would seem unlikely, but that this is possible appears from the following case.

N. R., a 21-year-old colored female, entered the hospital complaining of inability to use her legs. For about two weeks she had been unable to walk and had been confined to bed. Her past history was not informative except for the fact that a local physician had lanced an abscess on her right lower

[1] From the Department of Radiology of the Indianapolis General Hospital, Indianapolis, Ind. Accepted for publication in December 1948.

chest some two or three months earlier. The family history was of no significance.

The essential finding on the physical and neurologic examinations was a flaccid paraplegia, almost complete, of the lower extremities. There was hypesthesia at the xiphoid, but below that level all modalities were distinguished. Abdominal reflexes could not be obtained, but the reflexes of the upper extremities were normal. Large decubitus ulcers were present over the buttocks. The blood pressure was 110/70 and the lungs were clear. A small sinus was present over the right lower chest, at the site of the earlier abscess, but the drainage from this was negligible.

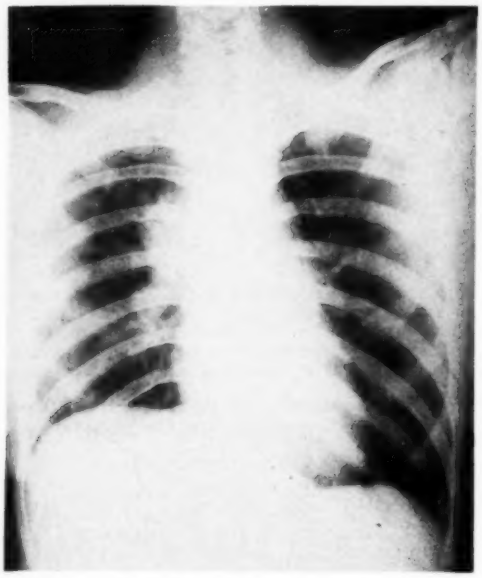

Fig. 1. Routine film of the chest showing a unilateral soft-tissue shadow projecting into the right lung field at the level of the 5th and 6th thoracic vertebral segments. Widening of the intercostal space between the 5th and 6th ribs is seen and on the original film bony erosion of the adjacent borders of these ribs could be made out. The outer border of the soft-tissue shadow is sharp and clearly delineated and roughly circular in outline. Incidentally, absence of the axillary portion of the right 9th rib, is seen.

The clinical impression was that of a myelitis below the 7th or 8th dorsal spinal segment, with or without a lesion of surgical significance above this level at the 5th or 6th dorsal segment.

Roentgen study of the chest and films of the thoracic spine revealed a soft-tissue shadow with a sharply delineated outer border protruding from the right paravertebral and mediastinal structures into the right lung field at the level of the 5th and 6th dorsal vertebral segments. Widening of the intercostal space between the 5th and 6th right ribs

Fig. 2. Right anterior oblique view demonstrating the unilateral soft-tissue shadow on the right side of the 5th and 6th thoracic segments. Slight widening of this intercostal space and erosion of the articular tubercle of the right 5th rib and of the transverse process of the 5th vertebra can be seen. The intervertebral disk spaces are well preserved. The bony make-up of the thoracic vertebral bodies appears normal.

associated with bony erosion of the adjacent borders of these ribs, erosion of the articular tubercle of the 5th rib, and of the transverse process of the 5th thoracic vertebra, were noted. No definite evidence of bony destruction of the vertebral bodies such as would be encountered in an infectious condition was seen and the intervetebral disk spaces appeared to be well preserved. The postero-mesial pleural line was clearly demarcated on the left and was not displaced by the soft-tissue shadow situated paravertebrally on the right. Incidentally, a partial absence of the 9th right rib in its axillary aspect was noted. There was no sign of active destruction in this rib, and it was believed that a part of it had been resected in the past.

Myelographic study with pantopaque revealed an almost complete block at the level of the 5th dorsal intervertebral disk. Only a trace of the opaque medium passed beyond this level. Deviation of the opaque column to the right, as if by an extradural mass, was observed.

The roentgen findings were thought to be most consistent with and in fact almost diagnostic of a spinal neurofibroma of the dumb-bell type. The fact that the paravertebral mass was unilateral, as well as capable of producing bony erosion and separation of the adjacent ribs, was considered strong evidence in favor of such a diagnosis. The

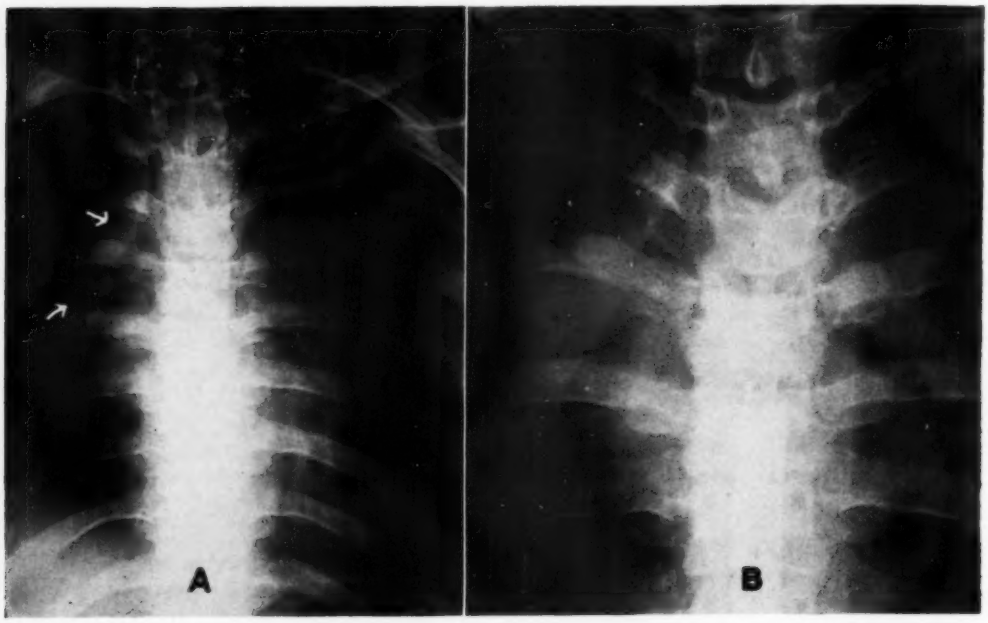

Fig. 3. A. Anteroposterior view of the thoracic spine showing definite widening of the intercostal space between the 5th and 6th ribs with erosion of the adjacent rib margins. There is destruction of a part of the articular head of the 5th rib and of the right transverse process of the 5th dorsal vertebra. The postero-mesial pleural line is clearly delineated on the left and is not displaced, this being further evidence against a tuberculous abscess, since the latter are practically always bilateral. Also the intervertebral disk spaces are well preserved and no sign of a tuberculous process in the vertebral bodies is seen.

B. Myelographic study showing the changes described above and demonstrating also the unilateral soft-tissue shadow of the abscess. There is practically a complete block at the level of the 5th thoracic intervertebral disk, with a defect in the opaque column that is almost hemispherical in form.

myelographic findings, showing an almost complete block, were held to be confirmatory.

Surgical exploration was done by Dr. E. Vernon Hahn and Dr. Paul Merrell of the Neurosurgical Staff, through a posterior approach. Caseous material was found at the level of the 5th and 6th spinous processes. Laminectomy showed granulation tissue over the anterior and posterior surfaces of the dura. An opening was encountered between the laminae of the 5th and 6th dorsal vertebrae. Further exploration revealed a large tuberculous cavity which extended anteriorly and laterally to the 5th and 6th dorsal bodies, conforming to the soft-tissue mass seen on the roentgenograms. The abscess was extrapleural and on removal of its contents the respirations of the underlying right lung could be counted.

The course of the patient was gradually downhill, although her general condition improved temporarily following surgery. She died twenty-three days after operation, probably from a tuberculous meningitis.

Undoubtedly some primary bony focus of tuberculous infection in the vertebrae was present in this case, even though it was not evident radiographically. A unilateral paravertebral abscess and adjacent bony destruction, apparently from extrinsic pressure, were the only roentgen features of the tuberculous involvement. The unilateral location of the abscess and the type of bony changes made a dumb-bell spinal neurofibroma a far more likely diagnosis, at least from the roentgen point of view. The partial absence of the 9th rib should have been more carefully considered. Evidently it represented another focus of tuberculous infection and had probably been resected for that reason, although no data on this were available.

The case is informing in the sense that it shows that tuberculosis of the spine can produce a unilateral spinal abscess, without bony changes in the associated vertebrae suggesting infection. The postero-mesial pleural line was identified in this case and

was seen not to be displaced. This is unusual in tuberculosis of the thoracic spine, since by far the most common finding is a bilateral paravertebral abscess shadow.

SUMMARY

1. A case of unilateral paravertebral tuberculous abscess in whicl. the roentgen findings were those characteristically found in dumb-bell neurofibromas of the spine is presented.

2. The importance of the postero-mesial pleural line as a thoracic roentgen landmark is stressed.

NOTE: The authors wish to express their deep appreciation to Dr. Paul Merrell and Dr. E. Vernon Hahn for the clinical material in this case.

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SUMARIO

Absceso Tuberculoso Unilateral de la Porción Torácica del Raquis Presentando los Hallazgos Roentgenológicos de Neurofibroma en Palanqueta

El caso presentado es de absceso tuberculoso paravertebral unilateral y los hallazgos roentgenológicos fueron los característicos de los neurofibromas en palanqueta de la espina dorsal. Una imagen de tejido blando con borde externo bien delineado proyectaba de los tejidos paravertebral y mediastínico derechos al campo del pulmón derecho a la altura de los quinto y sexto segmentos vertebrodorsales; el espacio intercostal entre la quinta y la sexta costillas del lado derecho estaba ensanchado y había erosión de los bordes adyacentes de esas costillas, del tubérculo articular de la quinta costilla y de la apófisis transversa de la quinta vértebra torácica. No había signos de destrucción ósea de los cuerpos vertebrales. La línea posteromesial no estaba desplazada.

Recálcase la importancia de la línea posteromesial como punto de referencia en la radiografía torácica.

Spontaneous Renoduodenal Fistulas[1]

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RENOVISCERAL fistulas developing without surgical or traumatic intervention, the so-called spontaneous fistulas, are relatively uncommon. They are the result of an inflammatory process in the kidney which invades an adjacent viscus. There may first develop a perirenal abscess which ruptures into the viscus. For a general review of spontaneous renovisceral fistulas, the reader is referred to papers by Higgins and Hicken (3) and Mertz (4).

The present communication deals specifically with spontaneous renoduodenal fistulas, which are particularly uncommon, only one case having been previously reported by American writers. A total of six cases have been found in the literature and these are briefly summarized below and in Table I. (A case described by Fernelius and cited by Higgins and Hicken (3) is omitted because the report is incomplete.)

Rayer's description of a case of Campaignac's in 1839 is the earliest record of spontaneous renoduodenal fistula. The patient, a 45-year-old female, had a tender swelling in the right side which decreased in size following episodes of vomiting foul urine-like material. The fistulous communication was found at autopsy.

Perry and Shaw (5) cite a case of Barlow's in which autopsy revealed hydatid cysts of the right kidney. These cysts had eroded into the duodenum. It was stated that the patient had vomited material corresponding to that found in the cysts. Perry and Shaw also cite a case of Turner's in which autopsy revealed pulmonary tuberculosis and tuberculosis of the right kidney, with fistulous communication between the kidney pelvis and duodenum.

Bang (1) reported a tuberculous renoduodenal fistula, found at autopsy, in a 22-year-old female. Tuberculosis was present in almost every organ. A right ureteral stricture and right hydronephrosis were present.

Another case secondary to tuberculosis was reported by Pulvertaft (6). The right kidney was pyonephrotic and contained many calculi. One calculus plugged a fistulous tract between the renal pelvis and duodenum. There was a severe scoliosis which, together with the infection and calculi, was thought to be responsible for the formation of the fistula.

The first case in the American literature was contributed by Biondi (2) in 1935. His patient was a 28-year-old white female with symptoms of dyspepsia and vomiting soon after eating. Pain radiated from the right flank around anteriorly to the right

TABLE I: REPORTED CASES OF RENODUODENAL FISTULA

Case	Year	Sex	Age	Etiology	Treatment	Outcome
1. Rayer	1839	Female	45	?	Conservative	Died
2. Barlow	1843	Female	26	Hydatid cysts	Conservative	Died
3. Bang	1874	Female	22	Tuberculosis	Conservative	Died
4. Turner	(Cited) 1893	Male	18	Tuberculosis	Conservative	Died
5. Pulvertaft	1935	Female	28	Tuberculosis with calculi	Conservative	Died
6. Biondi	1935	Female	28	Tuberculosis? Perforated ulcer?	Nephrectomy	Satisfactory
7. Present case	1948	Male	62	Pyelonephritis and perinephritis	Nephrectomy	Satisfactory

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Fig. 1. Anteroposterior view of the abdomen showing the calculi in the non-functioning right kidney. Figures 3, 4, and 5 show these to be obscured by the barium.
Fig. 2. Retrograde pyelogram showing the renoduodenal communication (upper arrows). Small bowel pattern of C-loop (lower arrows).

costal margin and down to the groin. A gastro-intestinal study was reported as showing periduodenal adhesions, but the fistula was demonstrated only by retrograde urography. Nephrectomy was eventually done, and the pathologist's examination revealed tuberculosis of the kidney.

The present case is reported as follows.

A. M., a 62-year-old white male, was admitted to Cleveland City Hospital on April 23, 1948, suffering from chronic urethral strictures. The immediate cause for admission resulted from his attempt to dilate his own strictures. He had inserted two large finishing nails into the urethra and was unable to remove them.

Past History: The patient gave a history of frequent episodes when he had been unable to pass urine. He had been admitted to this hospital one year previously for dilatation of urethral strictures. A suprapubic cystostomy was done at that time. There was no history of hematuria, but urgency and frequency occurred just prior to this admission. There were no gastro-intestinal symptoms.

Physical Examination: The patient was thin, appeared moderately ill, and was co-operative. The blood pressure was 140 systolic and 80 diastolic; the pulse was 86; respirations were 16; the temperature was 37.5° C. The eyes reacted to light and accommodation. Funduscopic examination revealed tortuous vessels with some streaking, but no exudates or hemorrhages. The ears, nose, mouth, and pharynx revealed no abnormalities. The anteroposterior diameter of the chest was increased. The lungs were hyperresonant. No râles or rhonchi were heard. The heart was not enlarged to percussion, and there was a regular sinus rhythm without murmurs. There was a midline scar in the lower abdomen. No neurological disturbances were demonstrated, and no skin lesions were found. The rectal examination revealed no abnormalities. Palpation of the penis outlined the two nails side by side within the urethra. The distal ends of the nails were about 2 cm. proximal to the external meatus. Penile urethral-cutaneous fistulas opened on the ventral side of the penis 2.5 cm. proximal to the external urethral meatus.

Laboratory Findings: The erythrocyte count was 4,000,000 and the leukocyte count was 9,800, with 80 per cent neutrophils and 20 per cent lymphocytes. The first urine specimen after removal of the foreign bodies was grossly bloody, and contained albumin and many white cells. The reaction was acid. Another specimen, examined two weeks later, revealed only 5 white cells per low-power field and no albumin. The blood urea nitrogen was 16.1 mg. per 100 c.c. The carbon dioxide-combining power varied between 40 and 52 volumes per cent. Kline diagnostic and exclusion tests were negative.

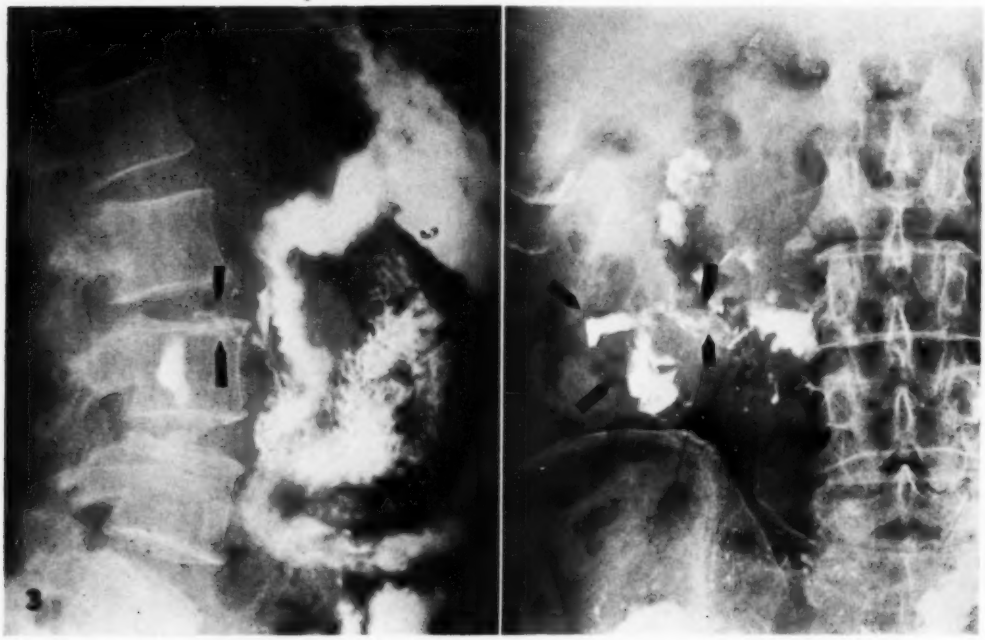

Fig. 3. Lateral view of abdomen made fifteen minutes after administration of barium meal. Arrows indicate fistulous tract between the kidney and duodenum. Barium, in the kidney, is outlined overlying the body of L-3.
Fig. 4. Anteroposterior view of the abdomen two hours after gastro-intestinal study. Kidney calices outlined by barium (arrows on left). Fistula indicated by arrows on right. The renal calculi are obscured by barium.

Hospital Course: The nails were extracted through one of the penile urethral-cutaneous fistulas with the use of small nasal foreign-body forceps. Attempts at extraction through the meatus were unsuccessful. The bladder and urethra were irrigated until clear return was obtained. There was no complete retention of urine after this procedure, although the patient did have considerable difficulty urinating. A soft rubber indwelling catheter was inserted into the bladder. Twenty-five thousand units of penicillin were given intramuscularly every three hours. Five grams of sulfadiazine were administered orally during each twenty-four-hour period.

Excretory urograms made the following day showed a non-functioning right kidney with calculi. The left kidney and ureter were normal.

Retrograde urograms, made five days after admission, showed a fistulous communication between the right kidney pelvis and the second portion of the duodenum (Figs. 1 and 2). Since the patient had no symptoms, signs, or past history to suggest this lesion, there was some doubt as to the interpretation of the films. Subsequently, an upper gastro-intestinal study was done to show the communication. Figures 3, 4, and 5 demonstrate the fistula between the kidney and duodenum.

Twenty days after admission, a right nephrectomy was done by Dr. Harry R. Trattner. This was accomplished under gas-oxygen-ether anesthesia and through a right lumbar incision. The kidney was one and one-fourth times normal size, but the color and configuration were normal, and no abnormalities could be seen through the capsule. The fistulous tract was found and isolated by blunt and sharp dissection. The tract was doubly clamped, then cut and ligated with chromic catgut. An attempt was made to invert the stump into the duodenum, but this was unsuccessful.

The postoperative course was satisfactory except for a superficial wound abscess which healed after surgical drainage. The patient was discharged thirty days after operation and has been followed for six months, with no complaints other than those referable to the urethral strictures.

The study of the surgical specimen, by Dr. W. A. Morningstar, revealed acute and chronic pyelonephritis, acute and chronic perinephritis, hydronephrosis, ureteritis, and acute and chronic inflammatory fibrous tissue (fistulous tract).

DISCUSSION

There is no question but that the majority of spontaneous renoduodenal fistulas develop secondary to a renal lesion. Biondi concluded that the fistula in his case was secondary to a perforated duo-

denal ulcer, since (*a*) the gastro-intestinal symptoms had preceded the renal symptoms; (*b*) there was no evidence of obstruction in the upper urinary tract; (*c*) no evidence of tuberculosis was observed on the retrograde studies of the kidneys.

Biondi's conclusion is questioned for several reasons. Obstruction in the upper urinary tract is not a necessary component in the development of a renoduodenal fistula. Excluding Biondi's case, 4 out of 6 cases cited in the present communication gave no evidence of upper urinary tract obstruction. Further, the assumed duodenal ulcer was not demonstrated by the gastro-intestinal study. An ulcer deep enough to penetrate should be easily demonstrable. Also, there is generally an acute abdominal crisis at the time of perforation, with shock and associated symptoms. No such history was given. And the fact that no evidence of renal tuberculosis was seen on the retrograde urograms of a kidney which subsequently was proved to be tuberculous is not a strong argument against a primary renal lesion.

The majority of workers agree that spontaneous renovisceral fistulas are secondary to a pathological process in the kidney. Ratliff and Barnes (7) reviewed the renocolic fistulas reported up to 1938 and found that all were secondary to a renal lesion. None were secondary to a lesion in the colon. Renoduodenal fistulas may eventually be shown to behave differently, but we believe that those cases reported so far indicate that the kidney is the source of the pathological process.

Biondi's case was the first diagnosed during life and the first successfully treated. Modern methods of examination will undoubtedly reveal other cases, and more information will be available for study of this unusual lesion.

Table I shows that those cases successfully treated had nephrectomies.

SUMMARY

The reported cases of spontaneous renoduodenal fistulas are reviewed and an additional case is presented.

Fig. 5. Anteroposterior view of abdomen three hours after administration of barium meal. Head of meal is in the ileum. A small amount of barium remains behind in the right kidney, outlining the middle and lower calices (arrows).

Present evidence indicates that the primary lesion leading to the formation of a spontaneous renoduodenal fistula always occurs in the kidney.

The treatment is nephrectomy and fistulectomy.

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SUMARIO

Fístulas Renoduodenales Espontáneas

En la literatura aparecen seis casos de fístulas renoduodenales espontáneas, que se repasan aquí, agregándoseles otro caso. En éste, los urogramas retrógrados revelaron la comunicación fistulosa entre la pelvis renal derecha y la segunda porción del duodeno, pero como no había síntomas, signos o antecedentes indicativos de dicha lesión, restó alguna duda acerca de la interpretación de las radiografías. Subsecuentemente, se verificó un estudio de la porción superior del tubo gastrointestinal, que reveló la fístula entre el riñón y el duodeno.

Los datos actuales indican que la lesión primaria que conduce a la formación de una fístula renoduodenal espontánea corresponde siempre al riñón. El tratamiento consiste en la nefrectomía y la fistulectomía.

A New Series of Radiopaque Compounds[1]

II. Further Notes on the Cholecystographic Uses of Certain Iodinated Hydroxyphenyl Fatty Acids

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A RECENT PAPER by Jones, Grohowski, Robertson, Ramsey, Schilling, and Strain on the use of 2-(4-hydroxy-3,5-diiodobenzyl)benzoic acid for the visualization of the gallbladder and extrahepatic biliary ducts in dogs (1) prompted us to review our notes on a similar project upon which we are still engaged (2). Our results with the use of certain 3,5-diiodo-4-hydroxyphenyl aliphatic and alicyclic acids were reported in 1946. In this series we studied but did not report on the compound described by Jones and his co-workers. This compound was prepared and tested by us on ten normal human subjects. It was then abandoned because the resulting gallbladder visualization twelve hours after the oral ingestion of doses of 3 and 5 gm. was considered less satisfactory than that obtained with related compounds. The material was well tolerated but was excreted rapidly through the urinary tract. Iodine excretion studies in four patients showed that 4.6 to 4.8 gm. were recovered from the urine and stool in forty-eight hours after the intake of 5 gm. No visualization of the extrahepatic biliary ducts was noted at that time or on recent re-examination of the films.

For human gallbladder visualization compounds are required which are relatively more fat-soluble, and the freedom from toxicity encountered in the series we reported encouraged us to proceed with our investigations. At the time of our original communication we had found that the product which afforded the best visualization was alpha-(3,5-diiodo-4-hydroxybenzyl)caproic acid. When this substance was prepared in the laboratory and used soon thereafter, there was practically no reaction after oral ingestion, and studies on laboratory animals with intravenous administration showed correspondingly low toxicity (3). It was found, nevertheless, that on standing for several months the compound became instable, causing diarrhea and epigastric distress in many patients. We therefore directed our search for a better cholecystographic medium to its related compounds.

One of the lines of investigation was to modify 2(4-hydroxy-3,5-diiodobenzyl)-benzoic acid so as to make it more fat-soluble. This was accomplished in two ways: first, by adding two methyl groups to the benzoic acid part of the molecule, as shown in Compound II below; and second, by preparing a compound with a reduced benzoic acid residue so as to produce a cyclohexyl group instead of a phenyl group (Compound III). Both of these compounds were found superior to the patent compound for use in the human subject. Of these, the preparation of Compound III is easier and it has been selected, therefore, for more intensive investigation, the results of which will be reported later (4).

It was believed that the relatively low melting point (98–100° C.) of the alpha-(3,5-diiodo-4-hydroxybenzyl)caproic acid might have been in some way related to the relative instability of the substance. The compounds at present under investigation have melting points of 181–195° C., which may contribute to their increased stability.

In the course of our studies, we also investigated the effect of removing the methylene group connecting the two rings.

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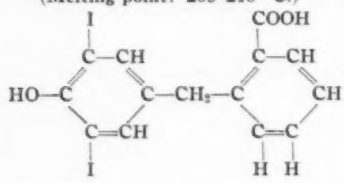
[1] From the Radiologic Service of M. G. Wasch, M.D., and the Pediatric Research Laboratory (B. Kramer, M.D.), Jewish Hospital of Brooklyn, Brooklyn, N. Y. Accepted for publication in November 1948.

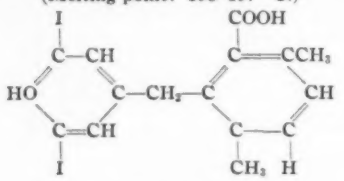
Compound I

2(4-hydroxy-3,5-diiodobenzyl)benzoic acid
(Melting point: 209–210° C.)



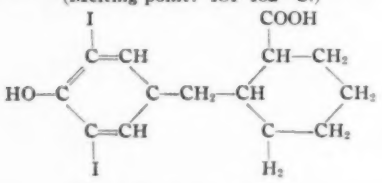
Compound II

2(4-hydroxy-3,5-diiodobenzyl)3,6-dimethylbenzoic acid
(Melting point: 195–197° C.)



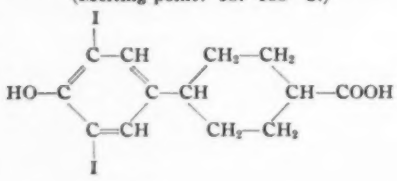
Compound III

2(4-hydroxy-3,5-diiodobenzyl)cyclohexyl carbonic acid
(Melting point: 181–182° C.)



Compound IV

4(3,5,diiodo-4,hydroxyphenyl)cyclohexyl carbonic acid
(Melting point: 187–188° C.)



This resulted in Compound IV, which resembles Compound I in its tendency to produce rather poor gallbladder visualizations. All four compounds, however, are well tolerated and are stable. Tests on samples which have been allowed to remain on the laboratory shelf for eight months in ordinary colorless glass bottles have shown very little evidence of the production of untoward symptoms after oral ingestion.

Jones and his co-workers state that the dog is the most satisfactory laboratory animal for the study of cholecystographic media. In our previous communication we pointed out that the compounds most suitable for gallbladder opacification in dogs are relatively less fat-soluble and produce poorer visualization in man because of their tendency to pass through the urinary tract. For this reason, dogs cannot be considered adequate subjects for experimentation in relation to the clinical application of various substances for human cholecystography, although they are well suited for toxicity investigations.

Routine visualization of the extrahepatic bile ducts in man is still to be attained, although Sussman has indicated that these structures may be opacified if a suitable meal is administered after cholecystographic examination. He also reported that under unusual circumstances the hepatic ducts may be seen (5 and 6). These studies require detailed and painstaking efforts, and any substance which would eliminate the attendant difficulties would indeed be a contribution. Whether this will be accomplished with newer media in man remains to be seen, but our present results in this direction are disappointing.

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SUMARIO

Nueva Serie sobre los Compuestos Radioopacos
II. Más Notas sobre las Applicaciones Colecistográficas de Ciertos Acidos Grasos Hidroxifenilicos Yodados

En un trabajo reciente (Radiology 51: 225, 1948) Jones y colaboradores comunicaron el empleo del ácido 2-(4-hidroxi-3,5-biyodobencilo)benzoico para la visualización de la vesícula biliar y los conductos biliares extrahepáticos en los perros. En 10 sujetos humanos normales, los AA. obtuvieron con esa sustancia visualización de la vesícula biliar menos satisfactoria que con otros compuestos afines, y en ninguno pudieron observarse los conductos extrahepáticos. Las modificaciones del medio para hacerlo más liposoluble dieron resultados considerados superiores en el hombre. Un compuesto, el ácido carbónico 2-(4-hidroxi-3,5,biyobencil)ciclohexílico, es objeto de intenso estudio y formará el tema de una comunicación en el futuro.

Further Studies on the Influence of Dose Fractionation on the Lethal X-Ray Effect Produced by Total Body Irradiation in Mice[1]

FRIEDRICH ELLINGER, M.D.[2] and JAMES C. BARNETT, M.D.

THE INFLUENCE of dose fractionation upon the lethal effect of total body roentgen irradiation on mice has been previously reported (1). The present paper describes the change in effect of the absolute lethal dose LD^{100} of x-rays in mice, with fractionation into single doses of various sizes and when different over-all exposure times are employed.

METHODS

A total of 220 white male Swiss mice were used in this experiment. Twenty of these served as unirradiated controls. The irradiation factors employed were as follows: 200 kv.p., 10 ma., 0.25 mm. Cu and 1.0 mm. Al total filtration, corresponding to a half-value layer of 0.75 mm. Cu. The intensity of the radiation was 23.4 r/min. and the target-skin distance was 50 cm. A field 20 × 20 cm. was employed, and the set-up for the exposures was the same as in our previous experiments (2).

The doses used were as follows:

A. 1,000 r was given to 63 mice in a single exposure.

B. 1,000 r was given to 40 mice, using 100 r daily on ten consecutive days.

C. 1,000 r was given to 33 mice over a sixteen-day period, with single doses of 100 r.

D. 1,000 r was given to 21 mice over an eighteen-day period, 12 doses of 75 r and 2 doses of 50 r being administered.

E. 1,000 r was given to 41 mice over a twenty-day period, in 50 r doses.

The method of recording deaths and the presentation of the results are as previously described. The days after exposure were used as abscissa and the percentage mortality as ordinate values (Fig. 1). For correct comparison, the graphs for the animals treated by fractionation have been transformed in such a manner that the zero day in a fractionated group is the day on which the total dose in that group has been accomplished.

RESULTS

Our results are summarized in Figure 1. Comparison of curves A and B shows that simple dose fractionation with one-tenth of the lethal dose (B) reduced the mortality rate from 100 per cent to 90 per cent. A slightly greater reduction was obtained in the mortality rate when the same single dose was employed, but the time of exposure was extended from ten to sixteen days (curve C).

However, the reduction in mortality rate becomes strikingly pronounced when the single exposures are reduced to 75 r per dose and the time extended to eighteen days. Noteworthy is the fact that further reduction in the single exposure to 50 r and the over-all time to twenty days, produced only an insignificant additional decrease in mortality rate.

The general appearance of the animals was in agreement with the decrease in mortality rates, and it was noted that the severe radiation sickness produced with a single exposure of 1,000 r (2) became relatively less manifest as fractionation was increased. In group E, the physical appearance of the mice was almost indistinguishable from that of the controls.

Animals have been observed up to 230 days, and those that had survived for this period of time outwardly appeared normal, notwithstanding the fact that there was a considerable amount of pathological change noticeable at autopsy.

[1] From the Laboratory for Experimental Radiation Therapy, Long Island College of Medicine, Brooklyn, N. Y. This work was aided by grants from the John and Mary R. Markle Foundation, New York, N. Y., and the Schering Corporation, Bloomfield, N. J. Accepted for publication in January 1949.

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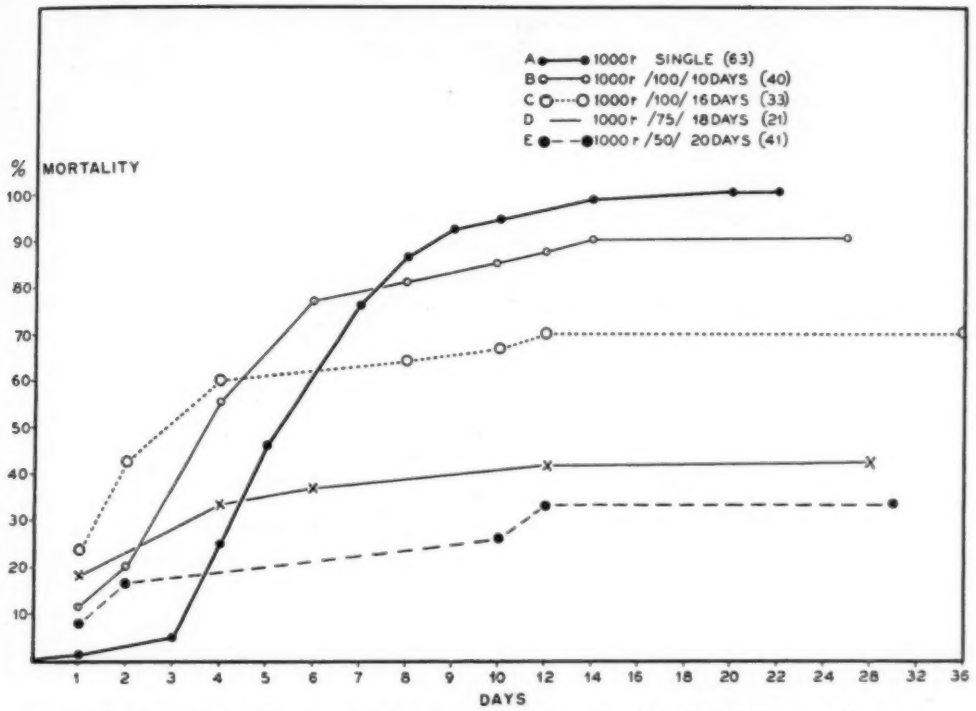

Fig. 1. Effect of dose fractionation on the lethal x-ray effect produced by total body irradiation in mice.

Changes in the spleen and bone marrow and fatty changes in the liver previously described in mice dying from the same doses given in a single exposure (1) were again encountered in the present group. Generally, however, the changes were delayed and less severe with increasing fractionation. Secondary infection was still noticed as late as the two hundred thirtieth day in the group treated with high fractionation.

DISCUSSION

Simple fractionation has been shown to decrease definitely the lethal effect of certain x-ray doses. In this series, however, both the time factor and the method of fractionation were altered in order to arrive more closely at the optimum time interval and single daily dose. Curve A in our graph (1,000 r single dose) shows a very rapidly rising death rate, with all the mice dead by the twentieth day. When the dose was fractionated for ten days, 100 r each day, the mortality rate reached 90 per cent and that peak was attained on the fourteenth day after cessation of irradiation. Then, as the time interval was increased to sixteen days, maintaining a 100 r dose for a total of 1,000 r, we noted a 70 per cent mortality rate, which was a drop of 20 per cent from the previous curve. This peak was reached on the twelfth day after discontinuation of exposures. The greatest drop was with the curve D, which showed a mortality rate of 42 per cent attained on the twelfth day after cessation of irradiation. In this manner the original 100 per cent mortality with the dose of 1,000 r/air given in single exposure was reduced to less than 50 per cent. The conditions of exposure used in this experiment appear to approach a certain optimum, since curve E indicates that a 30 per cent further decrease of the single exposure and consequent prolongation of the overall exposure time failed to increase the survival rate significantly. Only by still

further decrease of the size of the single exposure can a more significant decrease in mortality rate be obtained. Such procedure might, however, compromise an intended action of the x-rays on malignant tumor tissues.

The data presented in this paper reveal that in total body irradiation the effect of dose fractionation depends on the size of the single fraction as well as on the length of the over-all exposure time. It furthermore appears that the size of the single fraction to which a given dose is broken down is the more important factor for the decrease of the biologic effect.

It is hoped that ultimately in further studies iso-effect dose curves may be arrived at in the manner that Ahlbom (4) and Strandqvist (5) have developed for superficial neoplasms. Establishment of these data appears of great importance for a more rational treatment of widely spread malignant tumors.

SUMMARY

The influence of the size of the single exposure and over-all exposure time on the lethal effect of total body irradiation of mice with x-rays has been studied.

The effect of 1,000 r/air in one exposure (LD^{100}) was compared with that of the administration of the same dose when given in single fractions of 100–50 r/air within ten to twenty days.

It was found that the effect of dose fractionation in total body irradiation depends on the size of the single fraction as well as on the over-all exposure time. Of these two factors, the size of the fraction appears as the more important. It also appears that, as with observations on tumor destruction, there exists a certain optimum for dose fractionation in total body irradiation.

ACKNOWLEDGMENT: The authors wish to express their gratitude to Dr. A. L. L. Bell, Director of the Department of Radiology of the Long Island College of Medicine, for his kind interest in and support of this investigation. Miss Gloria Schonwit rendered valuable technical assistance.

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SUMARIO

Nuevos Estudios acerca del Influjo de la Fraccionación de la Dosis sobre el Efecto Letal Producido por la Irradiación Roentgen Total del Cuerpo en los Ratones

Este estudio versó sobre el influjo ejercido por la exposición aislada y la exposición global fraccionada sobre el efecto letal de la irradiación total del cuerpo de los ratones.

El efecto de 1000 r al aire en una exposición (DL100) fué comparado con el de la administración de la misma dosis, pero administrada en fracciones de 100–50 r al aire en término de diez a veinte días.

Observóse que, en la irradiación total del cuerpo, el efecto de la fraccionación de la dosis depende del tamaño de cada dosis dada así como del tiempo global de exposición. De esos dos factores, el tamaño de la fracción parece ser el más importante. También parece que, en forma semejante a lo observado en la destrucción de tumores, existe cierto punto óptimo para la fraccionación de la dosis en la irradiación total del cuerpo.

Further Studies on the Relation Between Radiation Effects, Cell Viability, and Induced Resistance to Malignant Growth

VI. Anomalous Radiosensitivities of Analogous Mouse Mammary Adenocarcinomas[1]

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IN EARLIER STUDIES on the effects of x-radiation on the proliferation of tumor particles (primarily of mouse sarcoma 180) grown *in vivo* and *in vitro*, it was shown that, while some 60,000 r were required to prevent growth *in vitro*, 4,000 to 5,000 r were sufficient to prevent growth *in vivo* (1). Experiments designed to offer some explanation for this difference yielded evidence that the tumor implants which were prevented from proliferating by the smaller dose were attenuated but not entirely destroyed, since animals implanted with the irradiated fragments became resistant, that is "immune," to further viable grafts of the tumor. Ehrlich, in 1905, originally observed this phenomenon of induced resistance; namely, that viable tumor grafts which fail to grow upon implantation induce resistance in the animal to further tumor grafts. Tumor implants destroyed by heat, formalin, or other means, failed to produce this "immunity."

Utilizing Ehrlich's observations as a test of viability, the author implanted mice with grafts of mouse sarcoma 180 previously irradiated with 60,000 r. These animals did not become resistant to implantation of further viable tumor grafts, thus proving that the dose of radiation required *in vitro* is actually the destructive dose, not only for the proliferation of the tumor cells, but also for the immunizing agent present in the cell. This work was first carried out on hybrid mice. In further experiments (2), similar results were obtained with a certain inbred strain of rats and a tumor autogenous to the strain (to avoid foreign body reaction); that is, tumor fragments attenuated with a specific dose of irradiation rendered a significant percentage of animals immune. However, with an inbred strain of mice, C57 black, negative results were obtained.

The observations set forth above led to further investigations. Experiments were designed to investigate tumors grown in inbred strains of animals, autogenous to the respective strains, regarding: (*a*) their radiosensitivity and (*b*) their immunizing properties. Such experiments have a twofold significance. On one hand, they may help to furnish information regarding threshold doses of radiation for tumors of various types grown in the hosts of origin; on the other hand, they may help to detect the immunizing potentialities of the tumors. Furthermore, there is an advantage in using inbred strains of animals and tumors autogenous to the strain. Since the host and the transplanted tumor are of the same genetic origin, the conditions are similar to those of spontaneous tumors. With the use of transplanted tumors, however, the material secured for experimental purposes is more homogeneous. It is known that spontaneous tumors contain a rather significant amount of fibrous connective tissue and various infiltrating cells; but when they are transplanted from host to host, the resultant tumors consist almost entirely of pure strains of cancer cells. Furthermore, the age of spontaneous tumors is usually not definitely known

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[1] From the Cancer Research Laboratory, Department of Hospitals, City of New York, and the Department of Biology, Washington Square College of Arts and Sciences, New York University. Presented at the Thirty-fourth Annual Meeting of the Radiological Society of North America, San Francisco, Calif., Dec. 5–10, 1948. An exhibit in conjunction with the presentation of the paper was unfortunately erroneously reported in RADIOLOGY (January 1949, pp. 262 and 265) under the title "Effects of Radiation on Normal and Malignant Tissue Cells."

This investigation was supported by grants from the National Cancer Institute, U. S. Public Health Service, and from the Damon Runyon Fund.

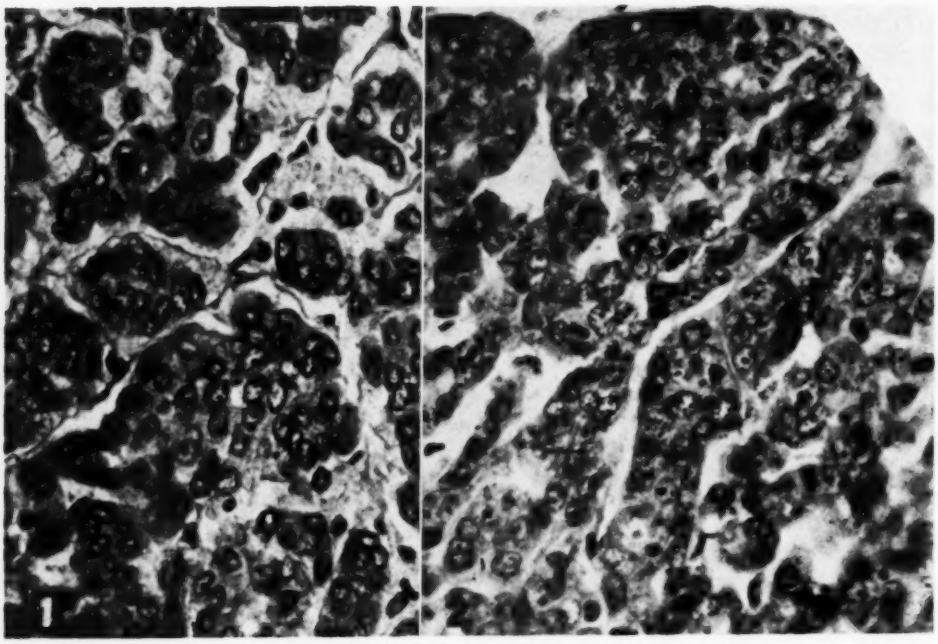


Fig. 1. Photomicrograph of a section of the mammary tumor of the C3H strain of mice. Note the acinic structures and the relatively small number of mitoses. ×500

Fig. 2. Photomicrograph of section of the mammary tumor (dbrB) of the dba strain of mice. Note the acinic structures and relatively large number of mitoses. ×500

whereas the age of transplanted tumors can be definitely determined, and their latent period can be established.

During the course of investigations, two inbred strains of mice, dba and C3H, and tumors originating in these strains, diagnosed as mammary adenocarcinomas, were used.

The C3H strain of mice was established in 1920 by Dr. Lionel Strong of Yale University and has been inbred since that time. These mice proved to have a high incidence (above 90 per cent) of spontaneous mammary tumors. A tumor which arose in this strain and which was diagnosed as an adenocarcinoma has been used for these experiments by transplanting it from host to host of the same strain. The tumor is firm in consistency and contains strands of epithelial cells, acinic structures, and some fibrous connective tissue (Fig. 1). The acini are relatively small in size, separated by a considerable amount of stroma. The tumor cells have a polymorphous, hyperchromatic nucleus, distinct nucleoli, and a distinct nuclear membrane. The rate of growth of the tumor is relatively slow: its latent period (the time elapsing between the implantation of the graft and the appearance of a tumor of measurable size, about 8 mm. in diameter) lies between twelve and sixteen days. The tumor grows progressively at a slow rate, attaining a diameter of some 25 mm. in about six weeks, and kills the animal within five to six months. The tumor has a definite tendency to necrosis.

The mice of the dba strain have been inbred at the Roscoe B. Jackson Memorial Laboratories, Bar Harbor, Maine, since 1918. In 1920, a tumor arising spontaneously in a dba mouse was microscopically diagnosed as adenocarcinoma, and designated as dbrB. It has been carried on since its discovery by means of successive transplants into mice of the same strain, resulting in 100 per cent "takes." This tumor grows rapidly: a graft produces a

tumor about 10 mm. in diameter within four to five days following implantation. The tumor kills the animal within two to three weeks, at which time it has attained a diameter of 30 to 40 mm. It becomes hemorrhagic within ten to twelve days. It is soft in consistency. Microscopically, it appears to consist of intra-acinar papillae with scant stroma (Fig. 2). The nuclear structure is rather uniform, usually reticular, with oval nucleoli and sponge-like cytoplasm, the nuclear membrane being somewhat more delicate than that of the C3H tumor. Figure 3 shows two tumor-bearing mice, one of the dba strain and one of the C3H strain, both implanted on the same date. The difference in size of the tumors is apparent.

In a previous study (3), it was demonstrated that fragments of the mammary tumor of the C3H strain of mice required a dose of about 2,800 r of filtered x-rays to prevent proliferation upon implantation into hosts of the same strain, while for implants of the more rapidly growing mammary tumor of the dba strain, a dose of about 5,000 r was required to obtain the same effect. This observation was contrary to expectations, since faster growing tumors are considered to be more radiosensitive. In further experiments (4), in which fragments of both tumors were irradiated *in vitro* and cultivated *in vitro* instead of in the animal organism, the relative radiosensitivities proved to be reversed. Thus, a dose of about 130,000 r was required for explants of the slower growing mammary adenocarcinoma of the C3H strain, while a dose of about 80,000 r was sufficient to prevent the proliferation of the explants of the faster growing tumor of the dba strain. That larger doses of radiation are required for cell destruction *in vitro* than *in vivo* has previously been demonstrated by various investigators (5–13).

The present experiments are an extension of the foregoing studies in which the two analogous adenocarcinomas of strains dba and C3H were treated with filtered x-rays *in vivo*, that is, in the animal organism.

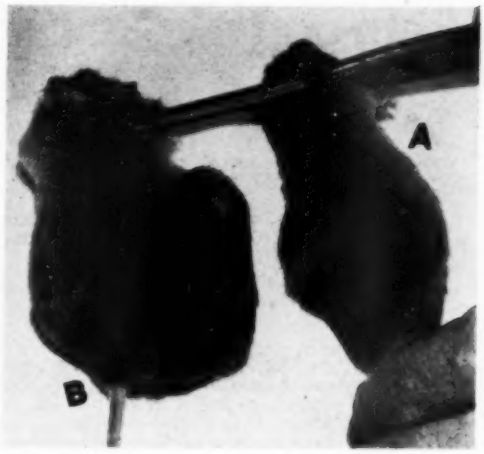


Fig. 3. Mice of the C3H strain (A) and dba strain (B). Both animals were implanted on the same day. Note the difference in size of the tumors produced in the same period of time. The tumor of the dba (B) mouse is about three times as large as that of the C3H mouse (A).

MATERIALS AND METHODS

There were used in this study 368 mice of the C3H strain and 219 of the dba strain. The mammary tumor, dbrB, of the dba strain and the mammary tumor of the C3H strain have been carried on in the author's laboratory for the past three years by transferring tumor fragments from host to host of the respective strain by implantation. The mice of both strains were obtained principally from the Bar Harbor Laboratories. When that source of supply was temporarily discontinued due to the fire at Bar Harbor, attempts were made to obtain the animals from other sources. A number of mice of both strains were obtained through the courtesy of Dr. John Bittner of the University of Minnesota; others who came to the author's aid, and to whom she extends her thanks, are Dr. Tannenbaum of Chicago, Drs. Haushka and Green of Philadelphia, and Dr. Eisen of Columbia University, New York. Although the mice thus came from different places, they are all descendants of the original strains, dba and C3H, and retain their status as inbreds, as ascertained by those who supplied them. The mice were kept in metal cages, were fed with laboratory

Fig. 4. Protective chamber. The cylinder is made of lead 4 mm. thick. When the mouse is placed inside the cylinder, it is possible to lift the tumor through the opening; the lead rings are placed around the cylinder on either side of the opening, as close together as possible so as to embrace the base of the tumor. The entire tumor is then exposed, while the remainder of the animal is protected from stray radiation. One end of the cylinder is made in the shape of a cup, provided with air holes; the other end of the cylinder is closed with a cork to restrain the animal.

dog chow, and received water *ad libitum*. Twice a week carrots or lettuce was added to the diet.

The tumor implantations were done by means of a trocar. Measurements of the tumors were taken two to three times weekly with a vernier caliper. Tumors averaging in size 12 × 10 × 8 mm., or thereabouts, were exposed to filtered x-radiation.

To protect the animal from stray radiation, a new device (Fig. 4) was used, consisting of a lead cylinder 4.5 cm. long, made from a sheet 4 mm. thick. One end was in the form of a cup, having several air holes. An opening, 2.5 × 1.5 cm., was cut in the center of the cylinder, through which the tumor could be lifted and held in place by lead rings about 2 cm. in width and 4 cm. in diameter. The tumor was placed between the rings and lifted to such an extent that it was almost separated from the animal; strips of adhesive tape were necessary to keep the lead rings tight. The other end of the cylinder was closed with a cork to keep the mouse in place.

The physical factors used were 200 kv., 20 ma., 0.5 mm. Cu plus 1 mm. Al filtration; h.v.l. 1.0 mm. Cu. The distance between the x-ray source and the target was 12.5 cm. The dosage rate throughout the experiments was 657 r per minute (±5 per cent).

The following series of experiments were carried out:

(1) The tumors were treated *in situ* (*a*) with single massive doses of filtered x-rays and (*b*) with divided doses within certain intervals of time. In this series, the tumors were allowed to remain in the animal hosts, and either their continuous growth or regression was noted.

Fig. 5. A mouse of the C3H strain in which the original tumor was exposed to a single dose of 10,000 r. Note epilation, regrowth of gray hair, and some scarring at the site of exposure, where the treated tumor was located. The tumor seen in this figure is growing on the edge of the epilated area.

(2) Irradiated tumors were removed periodically from the animal organism for histologic studies. In this series, animals were sacrificed within certain intervals of time following irradiation and the tumors were excised and immediately fixed in 10 per cent formalin. Small tumors were cut in half and fixed; when the tumors were larger, with necrotic centers, only portions from the edge were excised and fixed for histologic studies. Sections were 5 microns thick and were stained with Harris' hematoxylin and eosin.

TABLE I: MAMMARY ADENOCARCINOMA IN C3H MICE TREATED IN VIVO WITH SINGLE DOSES OF X-RADIATION (200 kv., 20 ma., 0.5 mm. Cu plus 1.0 mm. Al; h.v.l. 1.0 mm. Cu; 657 r/min (±5%))

Experiment Number	No. of Mice Treated	Average Size of Tumor (mm.)	Dose (r)	No. of Cured Mice	Percentage of Cured Mice	Remarks
1	15	11 × 9 × 5	2,000	0	0.0	All treated tumors continued to grow.
2	15	12 × 10 × 6	3,000	2	13.3	Of 15 treated tumors 2 regressed. All others continued to grow.
3	24	12 × 9 × 5	4,000	6	25.0	In 1 of the 6 mice cured, another tumor developed in the inguinal region, remote from the first one, supposedly from cells which were not irradiated.
4	24	13 × 8 × 6	5,000	10	41.7	Arrest of growth occurred in all irradiated tumors, of which 10 regressed and 14 continued to grow.
5	24	12 × 9 × 5	6,000	13	54.1	Observations similar to those in Experiment No. 4.
6	24	12 × 8 × 6	8,000	18	75.0	Of 24 treated tumors 18 regressed within 2 to 3 weeks. The other 6 renewed their growth after a temporary decrease in size.
7	32	11 × 9 × 6	10,000	28	87.5	Twenty-eight tumors regressed within 2 to 4 weeks and 4 continued to grow.
8	20	12 × 10 × 7	12,000	20	100.0	This dose seemed to be the destructive one for this type of tumor, of an average size of 12 × 10 × 7 mm.

In this paper, only results obtained with single massive doses of radiation will be reported.

EXPERIMENTAL DATA

A. Results Obtained with Mammary Tumors of the C3H Strain Treated in Vivo: Results obtained with treated tumors in C3H mice are recorded in Table I. As previously mentioned, measurements of tumors were taken two to three times weekly with a vernier caliper. An arrest of growth, or a temporary decrease in size, of tumors receiving a massive dose of x-radiation was usually noted. For the sake of brevity, the results tabulated include only the percentages of regressed tumors. It should be stressed that only those mice were regarded as cured in which the tumor completely regressed and in which no recurrences were noted six to eight months later. Mice which died shortly after irradiation are not included in the tables.

It will be noted that no tumor regressed following a single exposure to 2,000 r. Of 15 tumors, 2 regressed (13.3 per cent) following exposure to 3,000 r; of 24 tumors, 6 (25 per cent) regressed following the exposure to 4,000 r. In one of these 6 mice, another tumor developed in the inguinal region, remote from the first one. Since the trocar containing the tumor implants passed through this region, it may be assumed that some viable tumor cells were located here, which eventually produced a tumor. This observation is of significance. It shows that a tumor may regress at one site in the organism, while at another site a tumor may develop simultaneously if potential tumor cells are present.

Arrest of growth and decrease in size in all of 24 tumors exposed to a dose of 5,000 r were noted. Of these, 10 (41.7 per cent) regressed completely; the remaining 14 renewed their growth within three to four weeks following irradiation. Similar observations were made with doses of 6,000 r, 8,000 r, and 10,000 r: arrested growth occurred in all tumors, and complete regression in a significant number.

Of special interest was the following observation. Of 32 tumors exposed to a massive dose of 10,000 r, 28 (87.5 per cent) regressed within two to three weeks following exposure; the other 4 tumors (12.5 per cent) decreased considerably in size within this period of time, but later started to grow. An additional 10,000 r was then given, and complete regression was obtained. Figure 5 shows one of the 4 mice in which the original tumor was exposed to 10,000 r. It will be noted that epilation and scarring occurred at the site of exposure of the first tumor. The tumor seen in the figure is growing on the edge of the epilated area. The question arises whether

TABLE II: MAMMARY ADENOCARCINOMA dbrB OF THE dba STRAIN OF MICE, TREATED IN VIVO WITH FILTERED X-RADIATION
(200 kv., 20 ma., 0.5 mm. Cu + 1.0 mm. Al; h.v.l. 1.0 mm. Cu; 657 r/min (±5%))

Experiment Number	No. of Mice Treated	Average Size of Tumor (mm.)	Dose (r)	No. Cured Mice	Percentage of Cured Mice	Remarks
1	15	13 × 10 × 7	2,000	0	0	No apparent effect on tumor growth was noticed with doses up to 5,000 r.
2	15	12 × 9 × 6	3,000	0	0	
3	15	14 × 10 × 8	4,000	0	0	
4	16	14 × 9 × 6	5,000	0	0	Temporary arrest of growth was noted, but none of the tumors regressed.
5	15	13 × 9 × 6	6,000	0	0	Similar to those in Experiment 4.
6	15	14 × 8 × 5	8,000	0	0	Similar to those in Experiment 4.
7	20	13 × 9 × 6	10,000	4	20	Of 20 tumors exposed to this dose, 4 regressed, and 16 continued to proliferate after temporary arrest of growth.
8	20	14 × 10 × 7	12,000	7	35	Of 20 tumors exposed to 12,000 r, 7 regressed. The others continued to grow.
9	20	13 × 10 × 6	15,000	13	65	Of 20 tumors exposed to this dose, 13 regressed. The others decreased in size but started to grow again.
10	15	12 × 9 × 6	16,000	..	..	An arrest of growth was noted in all tumors exposed to doses ranging from 16,000 r to 24,000 r. However, some of the tumors exposed to 16,000 r renewed their growth. Since a significant number of mice died before total regression of tumors occurred, it was not possible to express results in percentages.
11	15	14 × 10 × 7	20,000	..	..	
12	15	13 × 8 × 5	24,000	..	..	

this tumor was produced by tumor cells which recovered from exposure to this massive dose of radiation, or by tumor cells which escaped injury. This question will be brought up again in the discussion.

All 20 tumors treated with a single dose of 12,000 r regressed within two to five weeks following exposure. Figure 6 shows a group of cured mice of the C3H strain which are alive and in good condition ten months after treatment.

It is to be emphasized that 10,000 r and 12,000 r are average figures, and that the critical dose may vary considerably from these amounts. As can be seen in Table I, it is possible in a few instances to bring about regression of a tumor with only 3,000 or 4,000 r, while in others a dose of 10,000 to 12,000 r is required.

It seems difficult in biology to obtain fixed thresholds. This is particularly true in radiobiology, where several factors must be taken into consideration; for example, the number of viable cells present during time of exposure; the number of successful x-ray "hits" within the "sensitive volume" of the cell; the vascularity of the tumor and of the tumor bed; and the age of the tumor-bearing host. Thus, the statistical nature of these results must be carefully borne in mind, especially when applying them to specific instances. However, from the experimental data obtained from this study on the mammary tumor of the C3H strain of mice treated *in vivo*, it seems that with single exposures, the total destructive dose of filtered x-rays lies between 10,000 and 12,000 r for tumors of an average size of 12 × 10 × 6 mm.

B. Results Obtained with the Mammary Tumor, dbrB, of the dba Strain Treated in Vivo: Table II shows some typical results obtained with mammary carcinoma, dbrB, exposed *in vivo* to various doses of filtered x-rays. It is seen that doses up to 10,000 r failed to produce tumor regression. Of 20 tumors exposed to a single dose of 10,000 r, 4 (20 per cent) regressed, while of 20 tumors exposed to 12,000 r, 7 (35 per cent) regressed; and of 20 tumors exposed to 15,000 r, 13 (65 per cent) regressed. With higher doses, such as 20,000 r and 24,000 r applied in a single exposure, a great number of animals died before complete tumor regression occurred or shortly afterwards. This fact does not permit expression of results in terms of percentage; yet from the number of cured mice surviving, it may be

inferred that doses of 20,000 to 24,000 r, applied in a single exposure, produced complete tumor destruction.

Figure 7 illustrates a group of cured dba mice which survived the massive doses of 10,000 to 24,000 r. This picture was taken nine months after treatment. As can be noted, gray hair appeared on the epilated areas, the site of the former tumors. One

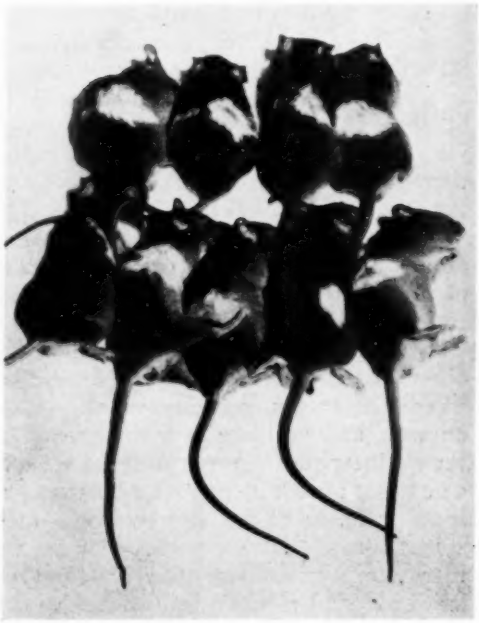


Fig. 6. Group of cured mice of the C3H strain, alive and apparently in good condition ten months after treatment. Note epilation and regrowth of gray hair at the tumor site.

unusual case is shown in Figure 8, that of a dba female mouse in which the tumor regressed following a dose of 24,000 r. At the time this picture was taken, a year and two months had elapsed since the regression of the tumor. The mouse is still in good condition.

It is of importance to stress the fact that tumors growing in old dba mice regressed after single exposures of 5,000 r. In these animals, obtained from the Cancer Institute of Columbia University, the tumors grew at a slower rate than those grown in young mice of the dba strain. The influence of age on the rate of tumor growth, and radiosensitivity, will again be brought up in the final discussion.

Fig. 7. Group of cured mice of the dba strain, nine months after total regression of the tumors. The mice are in apparently good condition. Note the regrowth of gray hair at the tumor site.

Discussion of Table I and Table II: A comparison of the data recorded in Table I and Table II reveals that tumors grown in C3H mice needed less dosage for their destruction than those grown in the dba strain. For example, a dose of 8,000 r applied in a single exposure produced regression of 75 per cent of the tumors in C3H mice, whereas there were no regressions in dba mice following such a dose. A dose of 12,000 r produced 100 per cent regression of tumors in the C3H mice, and only 35 per cent regression in the dba mice. From these observations, it becomes apparent that the two tumors differ markedly in radiosensitivity. The striking difference in the dosage required for total tumor destruction leaves no doubt that the mammary tumor of the C3H strain, a slower growing tumor, is more radiosensitive when grown *in vivo* than the faster growing dbrB tumor of the dba strain.

As previously remarked, it is difficult in biology to obtain fixed thresholds. At present, no definite explanation can be

Fig. 8. A female dba mouse in which the tumor regressed after a dose of 24,000 r. This picture was taken fourteen months after total regression of tumor. The mouse appeared in good condition. Note regrowth of gray hair at the tumor site.

offered for the wide range of dosage required for total tumor destruction of both mammary tumors, dbrB and C3H. This entire problem, as stated above, is intimately connected with the physical processes involved in the interaction of ionizing radiation with biological material. There seems little doubt, also, that the particular physiological activity of the treated subject at the time of irradiation is a significant factor. In an effort to throw some light on this problem, further experiments are being carried out with divided doses, and at varied intervals of time.

The method of exposure used in this study to protect the animal organism from stray radiation proved to be very satisfactory. This is evident from the long survival time of the animals treated with heavy doses of radiation, and their fertility. Figure 9 shows 2 cured females of the dba strain with litters produced two months following treatment.

In a previous report (14) the author stressed the high mortality occurring among tumor-bearing mice treated with 200-kv. x-rays. A similar high mortality rate was noted by other investigators, and was assumed to be due to the inadequate protection of the animal. The observation (see Fig. 1 of an earlier paper—14) that epilation and gray hair occurred on the site opposite that of the exposure (that is, on the "exit" side), and also on the legs of the animal, even though it was shielded by a lead cover, seems to confirm this assumption. It is believed that this difficulty may be overcome by the new device developed by the author (Fig. 4). In fact, the great number of cured mice, and their long survival following a massive dose of x-radiation, attest to its worth as a helpful tool in radiation experiments of this type.

C. Mitotic Activity Following Irradiation: One of the criteria used in evaluation of radiation effects in this study was mitotic activity following a given dosage. This was done in order to supplement the observations presented in Tables I and II, where the tumors remained in the intact animals, and no biopsies were taken. At certain intervals following exposures to specific doses of radiation, tumor-bearing animals were sacrificed by breaking their spinal cords. Surface portions of the tumor were excised and immediately fixed and sectioned as described above (p. 96).

It was originally planned to evaluate the results on a quantitative basis by analyzing the proportions of degenerate, resting, and dividing cells of the fixed and stained section. However, after observing renewed growth of a tumor forty-seven days following apparent regression in a dba mouse exposed to 16,000 r, and seventy days after apparent regression in a C3H mouse exposed to 6,000 r, this criterion seemed to be less significant. To illustrate this point reference is made to Figure 10, showing a C3H mouse. A new tumor appeared in the center of the epilated area where the original tumor had been treated. The new growth became noticeable when about the size of a pinhead (A) and developed to the size noted in B. It may be assumed that this new growth started from one or several

Fig. 9. Two cured females of the dba strain in which the tumors totally regressed after a dose of 12,000 r, and litters produced two months after treatment.

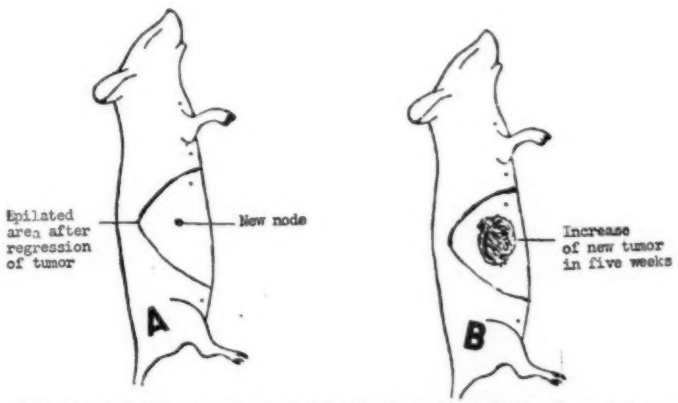


Fig. 10. Drawing of a mouse of the C3H strain in which the tumor had apparently completely regressed after a dose of 6,000 r. The tiny node (A), about the size of a pinhead, was noted on the epilated area thirty-five days after treatment. This node increased within five days to size B.

cells which escaped the effect of the heavy dose of radiation. To support this view, reference is made to Figure 11, which shows an actively dividing cell amid debris and necrosis in a C3H tumor, twelve days following exposure to 6,000 r. On the basis of the above observations it was decided for the sake of brevity to take, as a criterion of the effect of a dose of radiation, the greatest number of mitotic figures in a specific microscopic field of the entire tissue section, indicating their phases. Only some typical results will be reported here. (A more detailed analysis of cytological and morphological change, with illustrations, will be reported in a separate paper.)

D. Mitotic Activity in the Mammary Tumor of the C3H Strain Following Irradiation: No mitotic activity was noted in C3H tumors removed from one to twenty-four hours following exposure to doses of from 3,000 to 10,000 r, and these observations are not tabulated. Stress

TABLE III: MITOTIC ACTIVITY IN MAMMARY ADENOCARCINOMA OF THE C3H STRAIN OF MICE, TREATED IN VIVO WITH FILTERED X-RAYS

Experiment Number	Size of Tumor (mm.)	Dose (r)	Excised After Radiation (time)	Greatest Number of Mitoses in 1 Field (Average of 3 Tumors)	Phase				Comment
					Pro	Meta	Ana	Telo	
1	10 × 7 × 6	3,000	24 hr.	0	0	0	0	0	Each result represents an average of 3 tumors. Only some typical results of this experiment are reported. There were variations in mitotic counts under the same experimental conditions.
2	9 × 8 × 5	3,000	48 hr.	0	0	0	0	0	
3	12 × 9 × 6	3,000	9 days	4	1	2	1	0	
4	15 × 9 × 7	4,000	3 days	3	1	2	0	0	
5	12 × 8 × 7	4,000	17 days	7	2	3	1	1	Edge of tumor intact, with dense sheets of epithelial cells, mitosis. See Figure 12.
6	15 × 10 × 7	5,000	9 days	2	0	1	1	0	Much necrosis. Some portions of tumor intact, with rare mitoses.
7	9 × 7 × 5	6,000	4 days	2	1	1	0	0	Much debris. Necrosis. Edge of tumor intact, with rare mitoses.
8	15 × 13 × 13	6,000	70 days	3	0	1	2	0	Edge of tumor contained mitoses. Center was necrotic. The original tumor decreased in size but later started to grow again (Fig. 19).
9	14 × 11 × 7	8,000	6 days	1	1	0	0	0	See Figure 13.
10	12 × 8 × 5	10,000	5 days	1	0	1	0	0	
11	11 × 6 × 4	12,000	5 days	0	0	0	0	0	See Figure 14.

has been placed rather on mitotic activity occurring in tumors removed within longer intervals following exposure. Analysis of results recorded in Table III reveals that no mitosis was present forty-eight hours following a dose of 3,000 r, but that active mitosis appeared afterwards, and on the ninth day following irradiation there were 4 dividing cells in one microscopic field. These were present on the edge of the tumor section, while the center contained necrotic material. Apparently normal dividing cells were present three days following exposure to 4,000 r: 3 in one field—one prophase and 2 metaphases; and tumors removed seventeen days following exposure to an equal dose showed greater mitotic activity: 7 mitoses in one field—3 metaphases, 2 prophases, 1 anaphase, and 1 telophase. This pattern resembles that of a control, non-irradiated tumor section, and would seem to indicate that recovery or continuous growth of the irradiated tumor took place. Figure 12 illustrates this observation. As can be noted in this photomicrograph, mitotic figures are present in the intact sheets of epithelial cells which constitute the edge of the tumor section.

In some instances, apparently normal dividing cells were seen in tumor sections following exposure to 5,000 r, although in other instances tumors regressed following a similar dose. For example, in Experiment 6 (Table III) two dividing cells (1 metaphase and 1 anaphase) were found nine days following exposure to 5,000 r.

As previously mentioned, a renewal of growth occurred seventy days following exposure to 6,000 r. Since this is a sporadic case, it deserves a detailed description: A tumor 15 × 13 × 9 mm. in diameter grown in a female mouse of the C3H strain gradually decreased in size to 5 × 4 × 3 mm., after exposure to 6,000 r. Later, however, the tumor started to increase in size. To ascertain the viability and cell type of the tumor, the animal was sacrificed when the tumor reached the size of 9 × 6 × 5 mm. An inspection of the fixed and stained section revealed mitotic activity on the edge of the tumor, while the center was necrotic. It should be remembered that this type of tumor has a tendency to

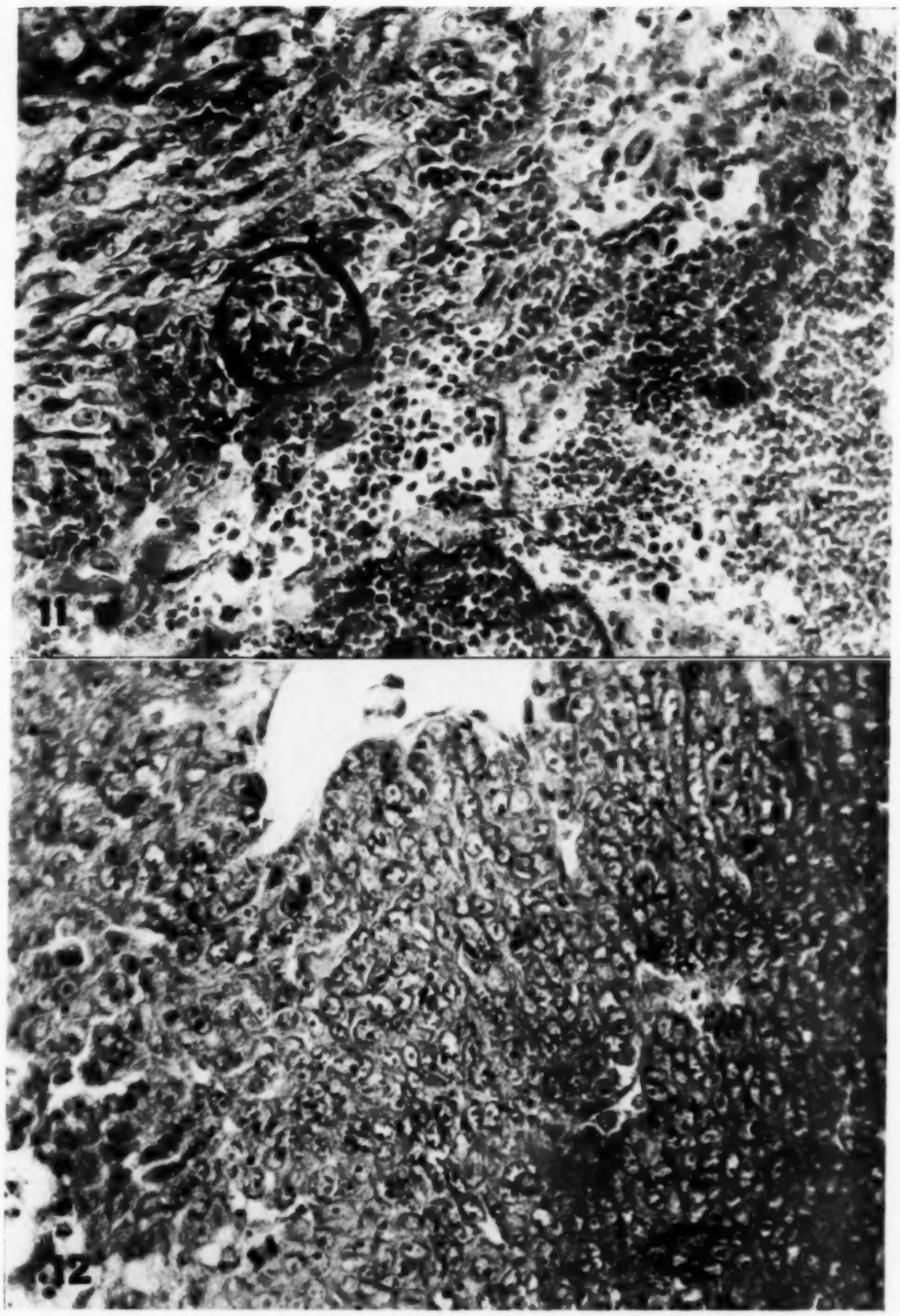


Fig. 11. One mitotic figure amid debris and necrosis in a mammary tumor of the C3H strain twelve days following exposure to 6,000 r. ×500.

Fig. 12. Section of a mammary tumor of the C3H strain seventeen days following exposure to 4,000 r. Note the intact sheets of cancerous epithelial cells and mitoses. ×500.

TABLE IV: MITOTIC ACTIVITY IN MAMMARY ADRENOCARCINOMA dbrB OF THE dba STRAIN OF MICE, IRRADIATED IN VIVO WITH FILTERED X-RAYS

Experiment Number	Size of Tumor (mm.)	Dose (r)	Excised After Radiation (time)	Greatest Number of Mitoses in 1 Field (Average of 3 Tumors)	Phase				Comment
					Pro	Meta	Ana	Telo	
1	12 × 9 × 8	3,000	24 hr.	5	2	2	1	0	Each result represents an average of 3 tumors. Only some typical results of this experiment are reported. There were variations in mitotic counts under the same experimental conditions.
2	13 × 11 × 7	3,000	5 days	5	1	3	1	0	
3	9 × 7 × 5	5,000	48 hr.	4	2	2	0	0	
4	11 × 8 × 6	5,000	9 days	4	1	3	0	0	
5	12 × 11 × 8	10,000	24 hr.	5	1	3	1	0	
6	8 × 5 × 3	10,000	13 days	5	1	2	2	0	There were debris and necrosis, but the edge of the tumor was intact, with mitoses.
7	12 × 7 × 5	10,000	39 days	4	1	3	0	0	Tumor decreased in size 7 weeks after irradiation; later started to grow again. See Figure 15.
8	9 × 8 × 7	15,000	48 hr.	4	1	2	1	0	This is an unusual case. Other tumors exposed to the same dose did not show mitoses. See Figure 16.
9	11 × 10 × 7	16,000	11 days	12	3	8	0	1	This is an exceptional case with respect to the large number of mitoses following such a large dose of irradiation. See Figure 20.
10	8 × 7 × 6	16,000	47 days	3	0	3	0	0	Tumor decreased in size but later started to grow again. See Figure 18.
11	14 × 8 × 6	24,000	5 days	0	0	0	0	0	See Figure 17.

produce necrosis in the early stages of normal growth.

Active cell division was observed six days following a dose of 8,000 r. As can be noted in Figure 13, there is one anaphase in the edge of the tumor, while the center shows necrotic material and swollen cells. Mitotic activity was a rare occurrence after a dose of 8,000 r. However, support was obtained for the observation made in Experiment 6 (Table I), that of the tumors exposed to 8,000 r, 25 per cent continued to grow. In very rare instances mitosis was noted in tumors which were exposed to 10,000 r. One example is recorded in Experiment 10, Table III. This observation is in accord with that in Experiment 7, Table I, in which 28 (87.5 per cent) of 32 tumors exposed to a massive dose of 10,000 r regressed. No mitotic activity was noted in a C3H tumor following a dose of 12,000 r (Fig. 14).

E. Mitotic Activity in the dbrB Tumor of the dba Strain of Mice Following Irradiation: Table IV contains some typical observations made on the mitotic activity of the dbrB tumor of the dba strain following exposure to various doses of x-radiation. As previously stated, the greatest number of dividing cells and their specific phases present in one microscopic field of the fixed and stained tumor section were used as a criterion of effectiveness of a given dosage.

Five dividing cells in one field were found in a section of a dbrB tumor twenty-four hours following exposure to 3,000 r. Incidentally, the same number of dividing cells was found in another case five days following exposure to an equal dose. This observation would indicate that 3,000 r exerts no significant effect on cellular activity. Four dividing cells (2 metaphases and 2 prophases) were found in one microscopic field of a tumor section forty-eight hours following exposure to 5,000 r, while 4 were found in another case nine days after exposure to an equal dose. It is of interest to note the sequence of mitotic activity following exposure to 10,000 r. Five dividing

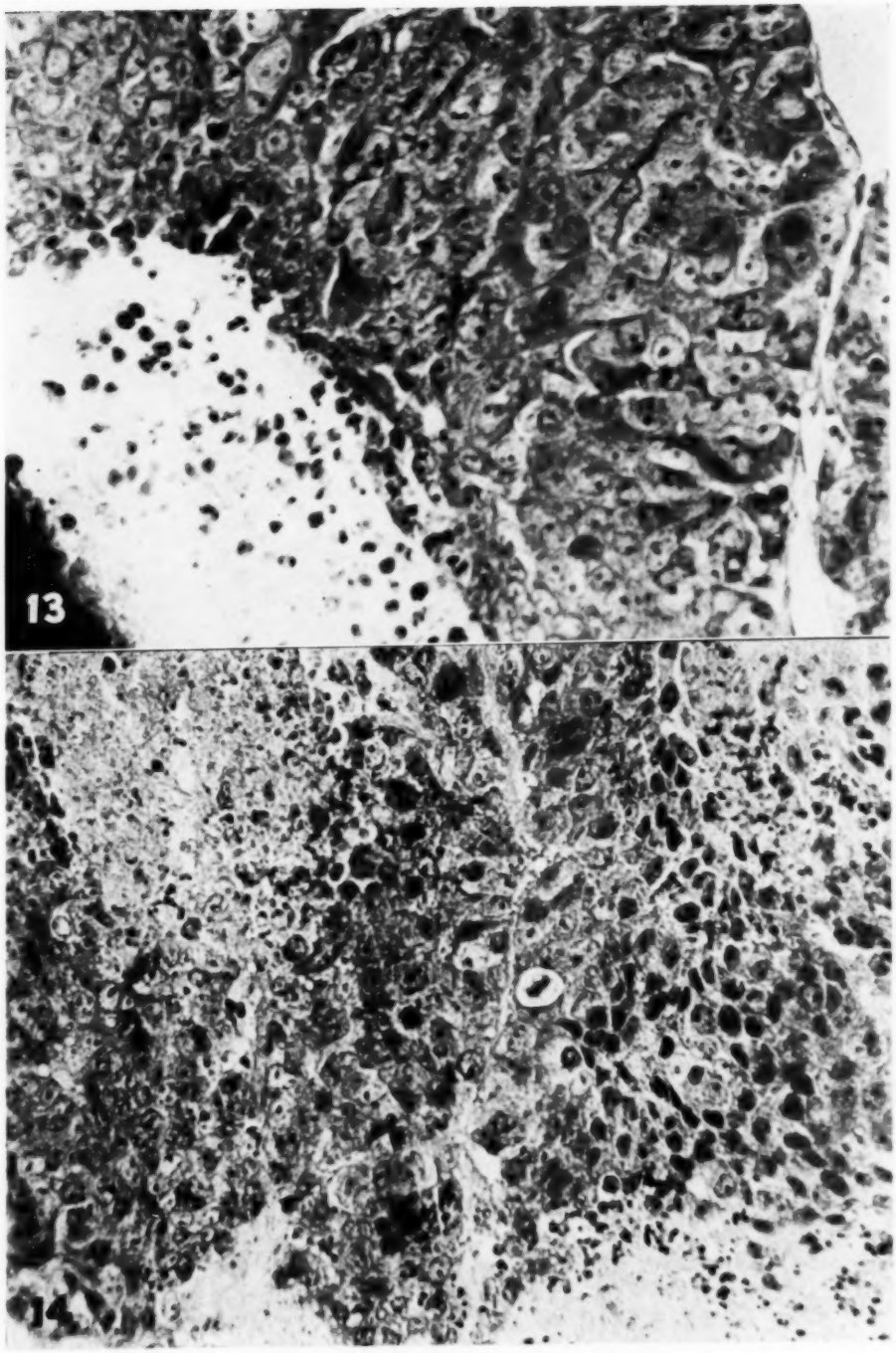


Fig. 13. Section of a mammary tumor of the C3H strain six days following exposure to 8,000 r. Note mitoses on the edge of the tumor, swelling of cells, and necrosis in the center. ×500.

Fig. 14. Section of a mammary tumor of the C3H strain six days following exposure to 12,000 r. Note the disintegrating cells. ×500.

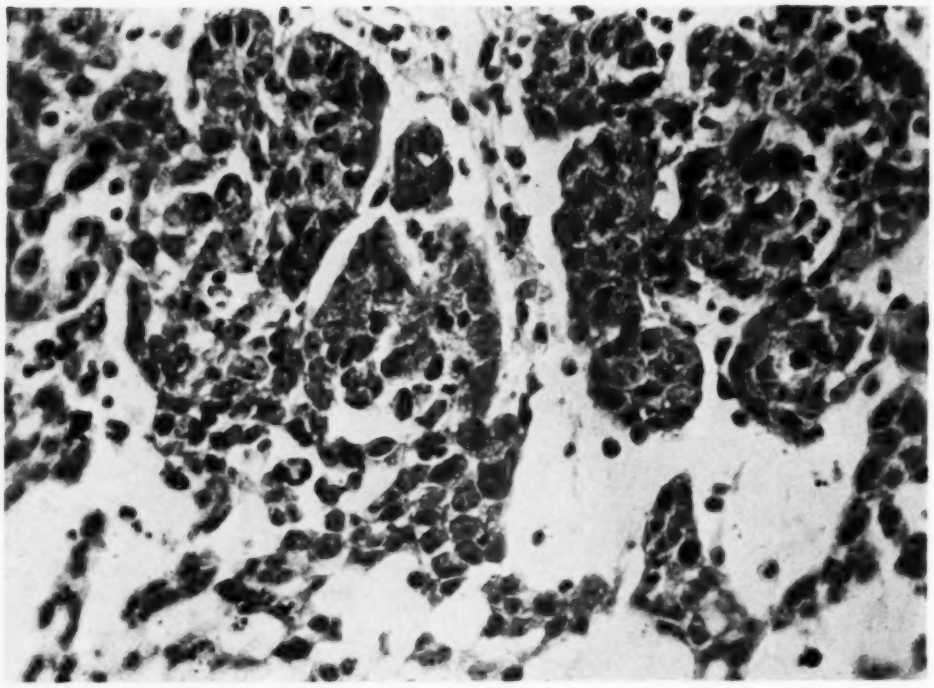


Fig. 15. Section of a mammary tumor (dbrB) of the dba strain thirty-nine days following exposure to 10,000 r. Note acinic structures and mitoses. ×500.

cells (1 anaphase, 3 metaphases, and 1 prophase) were found in one microscopic field of a tumor section twenty-four hours following exposure to 10,000 r. Incidentally, 5 dividing cells were also found in one microscopic field thirteen days after exposure to 10,000 r, and 4 dividing cells in one microscopic field thirty-nine days after exposure to this same dose (Fig. 15). This observation would again indicate that continuous proliferation took place in the tumor following a dose of 10,000 r. Although mitotic activity took place, nevertheless the normal pattern of the tumor was changed to some extent. This was noticed in the disorganization of the acini and shrinkage of the cell cytoplasm. The fact that mitotic activity occurred after a dose of 10,000 r supports the results set forth in Table II, namely, that of 20 tumors exposed to 10,000 r, 16 continued to grow.

Of interest is the observation made in Experiment 8 (Table IV). A section of a dbrB tumor removed forty-eight hours following exposure to 15,000 r, contained actively dividing cells as well as degenerate cells (Fig. 16). It should be stressed that in other cases where tumors were also exposed to a dose of 15,000 r, there were no actively dividing cells following exposure. It should also be recalled that of 20 tumors exposed to 15,000 r (Table II), 13 regressed completely (65 per cent), while 7 continued to proliferate. Similar observations were made with doses up to 24,000 r. The latter was the largest dose used in this study, and proved to be the destructive dose for proliferation of the dbrB tumor. Figure 17 illustrates the appearance of a tumor nine days following exposure to 24,000 r. There is no apparently viable cell to be seen in this figure.

Discussion of Mitotic Activity of the Mammary Tumors dbrB and C3H: From the data recorded in Tables III and IV, it appears that the extent of mitotic activity still remains the most reliable criterion where evaluation of tissue growth is concerned,

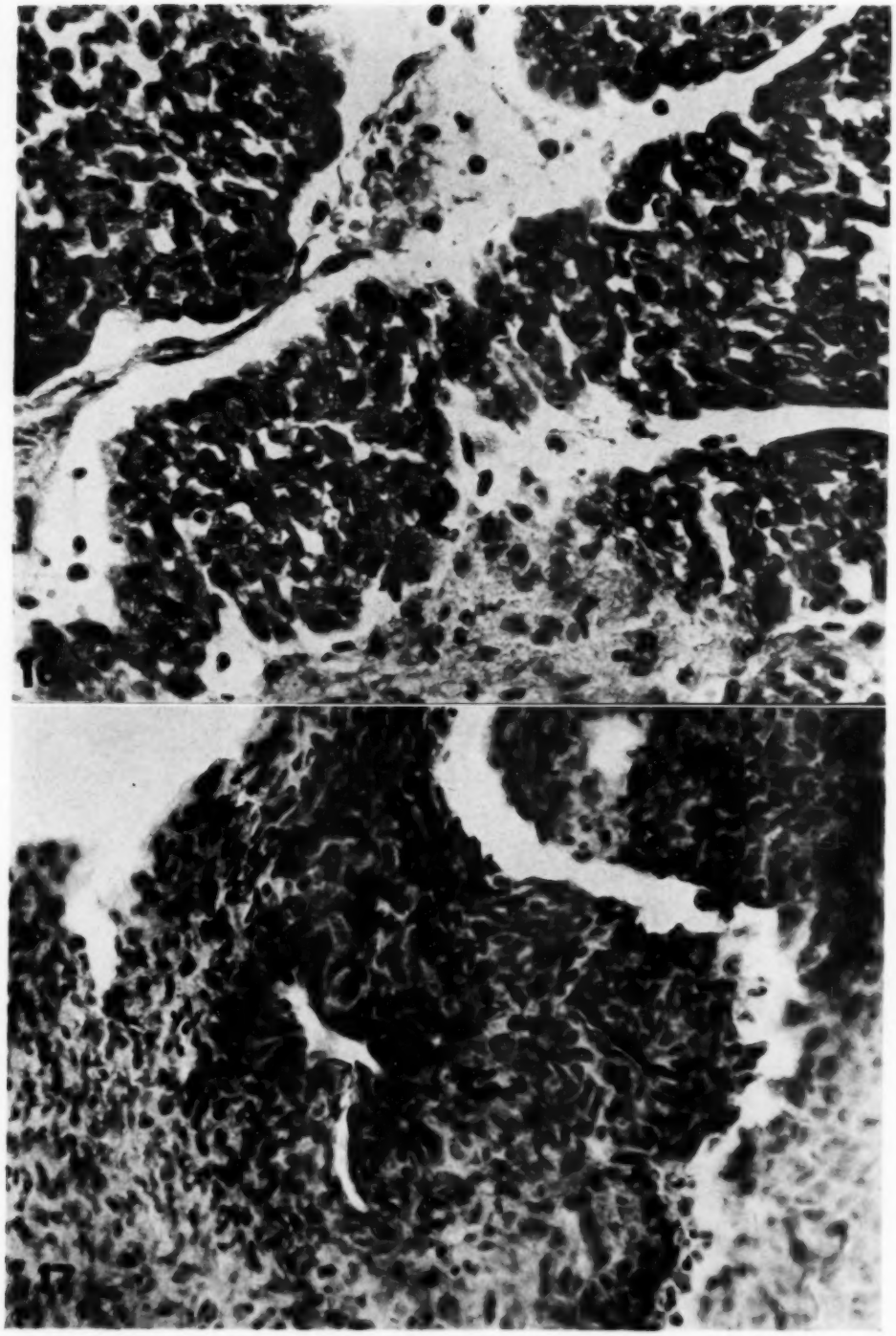


Fig. 16. Section of a mammary tumor (dbrB) of the dba strain forty-eight hours after exposure to 15,000 r. Note the acinic structures and mitoses. ×500.

Fig. 17. Section of a mammary tumor (dbrB) of the dba strain nine days after exposure to 24,000 r. Note disintegrating cells. ×500.

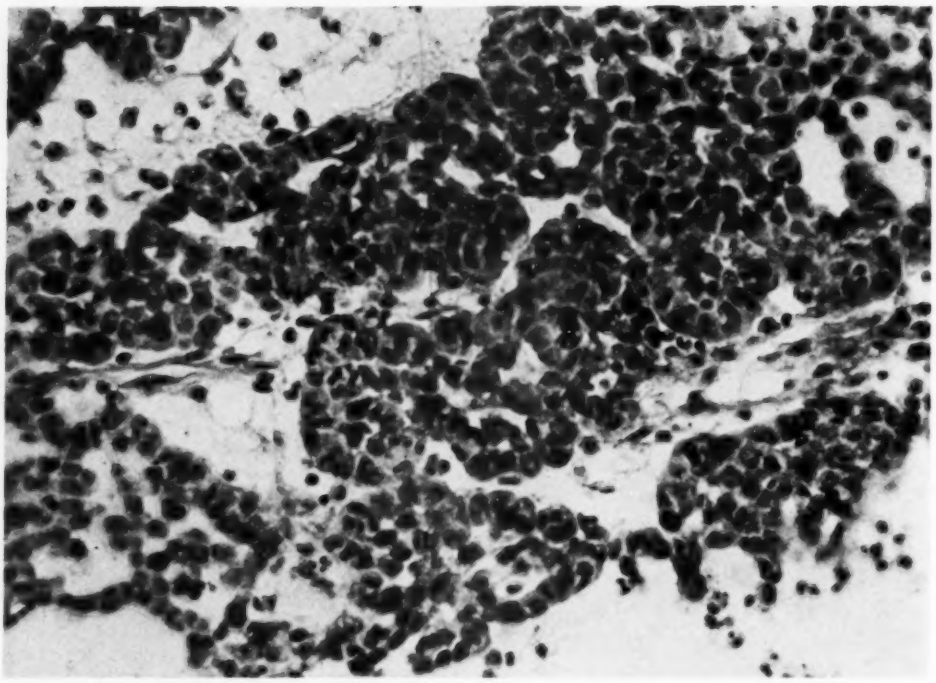


Fig. 18. Section of a mammary tumor (dbrB) of the dba strain forty-seven days after exposure to 16,000 r. Note change of pattern of tumor, as compared to Fig. 2, and mitoses. ×500.

and the utilization of this criterion is very helpful in determining the effective doses of radiation. The present study has shown that a few cells, or even one cell, remaining active in the tumor following a given dose of radiation, is sufficient to produce a new tumor. Reference is again made to the development of a new tumor in a dba mouse forty-seven days following a dose of 16,000 r (Fig. 18), and in a C3H mouse seventy days following 6,000 r (Fig. 19).

From the above observations and those following, it appears that recovery takes place faster in the dbrB tumor than in the C3H tumor. To illustrate this: no mitoses were seen in a section of the mammary tumor of the C3H strain twenty-four hours after exposure to 3,000 r, (Experiment 1, Table III), while in the dbrB tumor, 5 mitotic figures appeared in one microscopic field twenty-four hours after exposure to 3,000 r (Experiment 1, Table IV). Similar observations, made with larger doses, are recorded in the tables and demonstrated in the photomicrographs.

It is of interest to note in Tables III and IV that the metaphase was the predominant phase of the dividing cells present in a microscopic field of a fixed and stained tumor section. Figure 20 depicts this situation. Spear and Glücksmann (15), using tadpoles in their experiments, noticed that the first indication of recovery was the presence of metaphases in excess of prophases two to twelve days after exposure. The observations in the experiments herein reported seem to corroborate this.

From the observations made in this study, it appears that the presence of anaphases and telophases in the irradiated tumor may serve as a criterion in the prognosis of the efficacy of a given dosage of irradiation, since the pattern containing anaphases and telophases, in addition to metaphases, resembles that of a control, non-irradiated tumor.

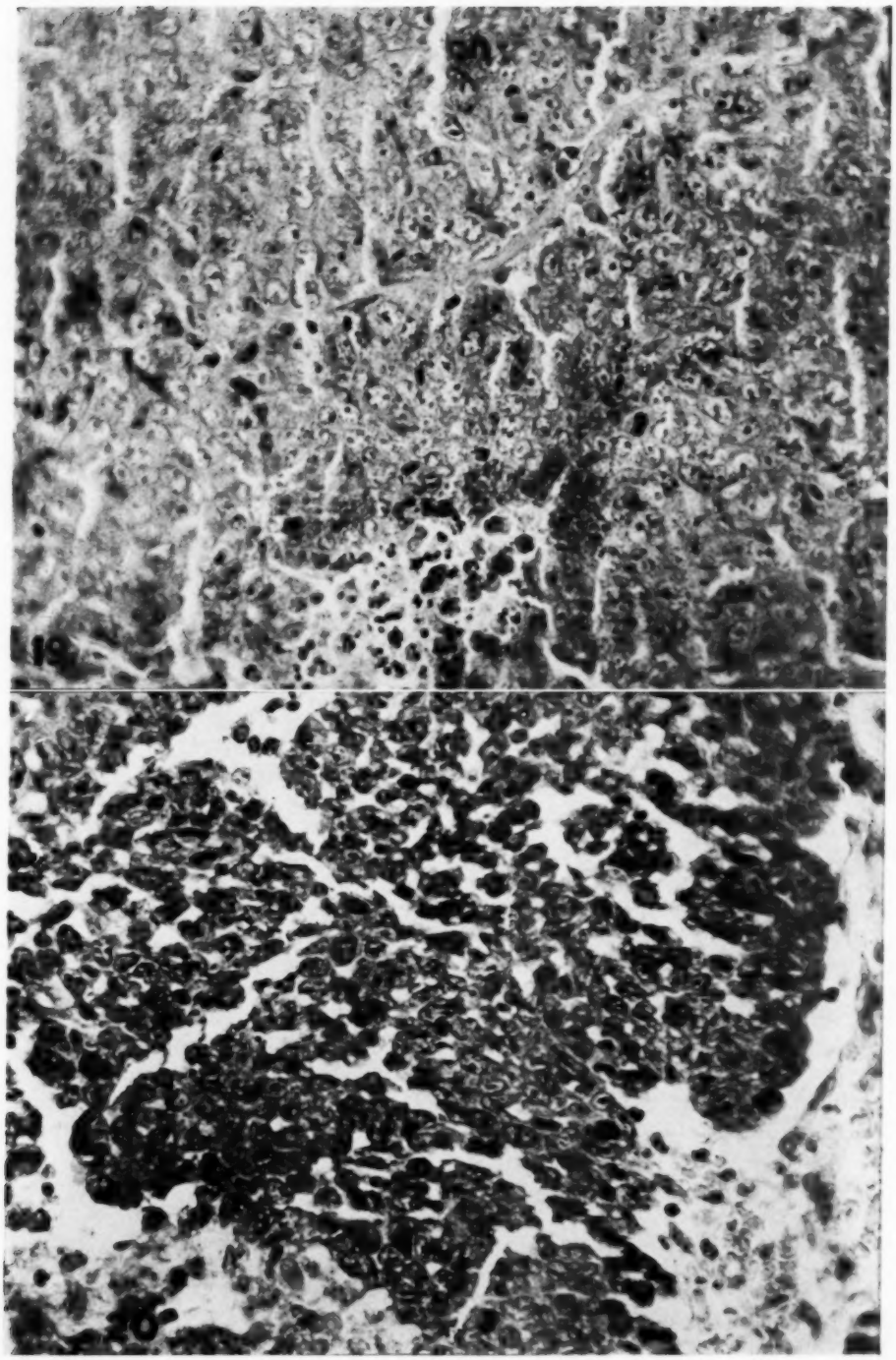


Fig. 19. Section of a mammary tumor of the C3H strain seventy days following exposure to 6,000 r. Note change of pattern of tumor, as compared to Fig. 1, mitoses, and disintegrating cells. ×500.
Fig. 20. Photomicrograph of a section of a mammary tumor (dbrB) of the dba strain eleven days after exposure to 16,000 r. Note the large number of mitoses in metaphase. ×500.

GENERAL DISCUSSION

A number of investigators have studied the response to radiation of normal and malignant cells grown *in vitro* and *in vivo*. Reference will be made only to recent investigations which warrant some comment in connection with this study.

Lasnitzki (16), using mammary carcinoma 63 grown in hybrid mice, produced regressions with doses ranging from 2,400 to 2,600 r. She obtained similar results with this tumor grown *in vitro* and concluded that the doses of radiation required for the destruction *in vitro* and *in vivo* are similar, except that a greater recovery occurs *in vivo*, which is attributable to the presence of blood supply, lacking *in vitro*. The results described in this paper show that much larger doses than mentioned by Lasnitzki are necessary for destruction of the mammary tumors.

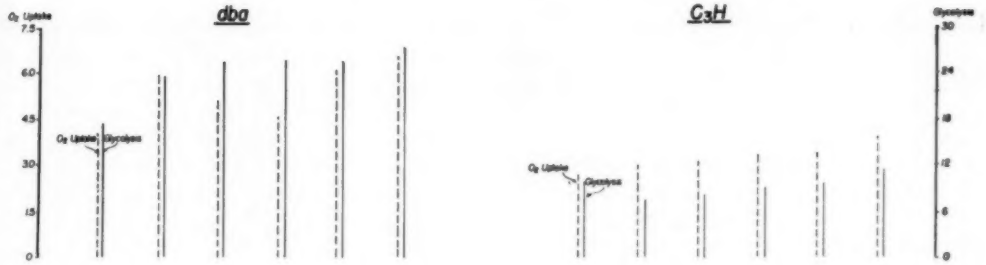
An explanation of this discrepancy may lie in the difference between the experimental procedures used. In her *in vivo* studies Lasnitzki used small tumors of "cherry size," grown in hybrid mice. In contrast, the author, working with inbred strains, used larger tumors, about the size of a walnut, autogenous to the strains. Reference is made to the observation by Oughterson *et al.* (17) that tumors grown in hybrid mice require less dosage for their destruction than those grown in inbred animals. With a dose of 5,000 r, they obtained 97 per cent cures in hybrid and only 48 per cent in inbred mice. In her *in vitro* studies, Lasnitzki irradiated tumor cells grown in the culture medium, whereas the author irradiated tumor particles and later placed them in a fresh culture medium. This was done because it had been noticed in previous studies (11, 18) that when the tissue cells are left in the irradiated medium, a smaller dosage is needed for their destruction than when they are removed and transferred from the irradiated culture medium to a fresh non-irradiated medium. Secondary effects of radiation on the culture medium were also noted by other investigators (19, 20).

Furthermore, as mentioned above, the author used tumor particles instead of single cells, because this method approximates clinical conditions, where whole tumors, and not single cells, are irradiated.

Luther (21), using the same type of tumor as Lasnitzki (mouse carcinoma 63), stated that he was unable to produce total cell destruction with a dose of 20,000 r. As mentioned above, Oughterson *et al.* (17) produced only 48 per cent regression of mammary tumors grown in inbred strains of mice with a dose of 5,000 r. This also indicates the necessity of larger doses of radiation for destruction of mammary tumors. It appears that a standard technic is desirable in order to secure reproducible results in various laboratories.

The outstanding observation made from the study herein described is that two analogous mammary tumors autogenous to two inbred strains of mice (dba and C3H), both diagnosed as adenocarcinoma, proved to differ widely in their physiological characteristics. This is evidenced by the difference in the rate of growth, radiosensitivity, and metabolic activity. The rate of growth, which may be gauged by the latent period, that is, the time elapsing between the grafting of the implants and the appearance of tumors of measurable size, was found to be in the proportion of about 1:3 for the two tumors (four to five days for the dbrB tumor and fourteen to sixteen days for the C3H tumor).

The difference in metabolic rate of these tumors was measured by oxygen consumption and glycolytic activity of tissue slices (Barcroft-Warburg manometric technic). The dbrB mammary tumor consistently proved to be two to three times more active in its metabolism than the C3H. Thus, for the dbrB tumor the metabolic rate was as follows: Q_{O_2}, 5.6 cu. mm. per mg. tumor tissue per hour; aerobic glycolysis ($Q_G^{O_2}$), 25.2 gamma lactic acid per milligram tumor tissue per hour. For the C3H tumor the oxygen uptake (Q_{O_2}) was 3.8 cu. mm. per mg. tumor tissue per hour, and the aerobic glycolysis ($Q_G^{O_2}$) was 8.6 gamma lactic acid per milligram tissue per hour. The above figures clearly demonstrate the



M

Graph M. This graph demonstrates the difference in metabolic rate between the mammary adenocarcinomas of the C3H and dba strains of mice, as measured by oxygen consumption and glycolysis of tissue slices *in vitro* (Barcroft-Warburg manometric technic). The dotted lines represent the O_2 uptake and the solid lines represent the glycolysis.

Note that the metabolic rate of the mammary tumor of the dba strain is about three times as high as that of the mammary tumor of the C3H strain of mice.

higher metabolic activity of the dbrB tumor (see graph M).

From the above observations, it may be concluded that where radiosensitivity is concerned the physiological activity of the cell might serve as a more reliable index than its morphological characteristics. In this connection, reference is made to the statement by Lacassagne (22) that the radiosensitivity of the developing rabbit ovum and its follicle depended not on their youthfulness, but on their function.

In contrast to the widely accepted belief that faster growing tumors are more radiosensitive than slower growing ones, it has been shown in previous experiments (3), and substantiated in the present studies, that although this is true of the mammary tumors studied when grown *in vitro*, it does not hold true *in vivo* (4). An explanation for this anomaly may be made in terms of the metabolic exchange, or "wash-away" effect, which is prevalent when the tumor is growing in the animal host. In this case there is ample opportunity for the quick removal of the toxic substances produced by radiation. When the experiments are carried out *in vitro*, in the absence of a vascular supply, the "wash-away" effect does not take place; and accordingly, the dbrB tumor was shown to be the more radiosensitive of the two.

The magnitude of this "wash-away" effect may be so great as to mask at times the actual behavior of the faster growing cell *in vivo*, where radiosensitivity is concerned. The results of the experiments *in vitro*, on the other hand, indicate how one may observe the potentialities of the cell, unobscured by the influence of the host.

The observations made in the present study support the conclusion previously drawn (4), that the Bergonié and Tribondeau law, which states "that the strongest effect of radiation is exerted on the least differentiated cells, and on those of greatest reproductive ability," holds true *in vitro*, but not *in vivo*. It appears that this law warrants revision. The difficulty in curing fast growing anaplastic tumors in man supports the above observation.

Another analogy to human tumors may be drawn from the following observations: active mitosis was found in the dbrB mammary tumor, when grown in a young host, forty-seven days after exposure to a dose of 16,000 r. This period corresponds to nearly five years in the life of a human being. In other words, assuming a similar malignant condition in man, that is, that some viable malignant cells remained after a course of x-ray treatment, one might expect that a new tumor would be produced during this period of time. Continuing

the analogy: in view of the fact that there are frequent recurrences of malignant growth within the five-year period following radiation therapy, particularly in young people, and in view of the results reported herein, it might be suggested that follow-up treatment for a period of five years is indicated. In support of the above suggestion, reference is made to observations of several investigators (23–25) who noticed viable cancer cells in human breast cancer within one year following treatment with doses up to 5,000 r.

Another point of interest is the influence of age upon the radiosensitivity of tumors. Mammary tumors when grown in old mice (a year and over) grew at a slower rate than the same tumors in young hosts, and required less dosage for their destruction. The faster growing dbrB tumor, when grown in old mice, could be made to regress with doses of 5,000 to 10,000 r, while the same tumor when grown in young mice, required doses of up to 24,000 r for its destruction. This observation brings out another analogy to human beings which is often noted, namely, that tumors in older persons grow at a slower rate and require less radiation.

The above findings bring forth more evidence that the activity of the tumor is an important factor where radiosensitivity is concerned. It would seem that a classification of tumors based on rate of growth and metabolic activity would serve as a more reliable criterion for determining radiosensitivity than a classification based on purely morphological characteristics.

Regarding the problem of induced resistance to malignant growth, only a few points will be mentioned here, since a more detailed report will be given elsewhere on this phase of the problem. A great percentage of the mice of the C3H strain (up to 80 per cent) in which the tumors regressed following radiation treatment became resistant to subsequent viable tumor grafts of the same type of tumor. Moreover, it was noted that fourteen months after regression of the tumors treated with radiation (at the time this paper is being written), spontaneous tumors had developed in none of these "immune" mice, in spite of the fact that the C3H strain of mice has a high incidence of spontaneous mammary tumors (up to 90 cer cent). In fact, a great number of spontaneous mammary tumors occurred among the control mice at the author's laboratory during this period of time.

The C3H strain of mice contains the so-called "milk agent," supposedly a virus, discovered by Bittner, which is considered to be responsible for the high incidence of mammary tumors in this strain. It appears, therefore, that irradiation inactivates the milk agent, making it function as an antigen. In fact, antigenic properties of the milk agent have been described by a number of investigators (26, 27). Various workers (28–32) have also shown that antigenic properties exist in the Rous chicken sarcoma and the Shope rabbit papilloma, tumors which are also thought to be of virus origin. Other types of tumors fail to produce the phenomenon of induced resistance; for example, the mouse mammary carcinoma in C57 black mice. Investigations have shown that this strain, C57, does not have the "milk agent" or virus. Assuming, therefore, the virus nature of the "milk agent," it appears possible that the causative agent in the production of "immunity" to malignant growth may be a virus reaction. If this theory is correct, it may throw light on the question originally posed by Ehrlich in 1905, as to the cause of the phenomenon of induced resistance to malignant growth in animals. Further work is in progress to ascertain the soundness of the tentative assumption made above.

SUMMARY AND CONCLUSION

Evidence has been presented that mammary adenocarcinomas grown in inbred strains of mice (dba and C3H), autogenous to these strains, differ in their rate of growth, metabolic activity, and radiosensitivity in the proportion of about 1 to 3. The faster growing tumor, dbrB of the dba strain, averaging in size about 12 × 10 × 8 mm., proved to require a larger

dose of irradiation for its total destruction (up to 24,000 r) when grown in hosts of origin, while the slower growing mammary tumor of the C3H strain, of similar size, required only about 12,000 r. The above observation, obtained from the present experiments *in vivo*, confirms the result of a previous experiment *in vivo* (3), and is in contrast to that obtained from experiments *in vitro* (4), in which the faster growing dbrB tumor proved to be less radiosensitive than the slower growing C3H tumor. This anomaly is explained by the greater metabolic rate of the more rapidly growing tumor, the "wash-away" of the toxic substances being more pronounced in the faster growing tumor when grown *in vivo*, thereby enhancing the recovery process. This view is supported by the fact that mitotic activity is resumed earlier in the faster growing dbrB tumor than in the slower growing C3H tumor, *in vivo*, following exposure to an equal dose of irradiation.

Other significant conclusions from this study are as follows:

(1) It appears that the Bergonié-Tribondeau law, which states that "the strongest effect of radiation is exerted on the least differentiated cells and on those of greatest reproductive ability," holds true *in vitro* but not *in vivo*.

(2) It would seem that a more reliable classification of tumors may be made on the basis of their biological or physiological characteristics, involving the fundamental activity of the cell, than on the basis of histological or purely morphological characteristics.

(3) The fact that in man there are frequent recurrences of malignant tumors within the five-year period following a course of radiation therapy, particularly in the young, would seem to bear out the trend of observations made on the mouse mammary tumors. Follow-up treatments within this five-year period would therefore seem to be indicated.

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SUMARIO

Nuevos Estudios sobre la Relación entre los Efectos de la Irradiación, la Viabilidad Celular y la Resistencia Inducida a los Tumores Malignos. VI. Radiosensibilidades Anómalas de los Adenocarcinomas Análogos de las Mamas Murinas

Los datos presentados demuestran que los adenocarcinomas mamarios plantados en razas entrecruzadas de ratones (dba y C_3H), autógenos para dichas razas, discrepan en la velocidad de su desarrollo, actividad metabólica y radiosensibilidad en una proporción de unos 1 a 3. El tumor de desarrollo más rápido, dbrB de la raza dba, promediando 12 × 10 × 8 mm. en tamaño, exigió para su destrucción total una dosis alta de irradiación (hasta 24,000 r) al desarrollarse en huéspedes del mismo origen, mientras que el tumor mamario, de desarrollo más lento, de la raza C_3H, aunque de tamaño semejante, sólo exigió unos 12,000 r. Esta observación fundada en los actuales experimentos *in vivo*, confirma el resultado de un experimento anterior *in vivo*, y contrasta con lo observado en experimentos *in vitro*, en los que el tumor dbrB de desarrollo más rápido resultó ser menos radiosensible que el C_3H de desarrollo más lento. Explica esta anomalía la aceleración metabólica del tumor de desarrollo más rápido, siendo más pronunciado el "arrastre" de las sustancias tóxicas en el tumor de desarrollo rápido al crecer *in vivo* y realzando así el proceso de reposición. Apoya esta opinión el hecho de reanudarse más pronto la actividad carioquinética en el tumor C_3H de desarrollo más rápido, *in vivo*, después de la exposición a una dosis igual de irradiación.

Otras importantes conclusiones de este estudio son las siguientes:

(1) Parece que la ley de Bergonié-Tribondeau, de que "la radiación ejerce su efecto más poderoso sobre las células menos diferenciadas y sobre las de mayor capacidad reproductiva," válida *in vitro*, no lo es *in vivo*.

(2) Parece que cabe hacer una clasificación más exacta de los tumores a base de sus características biológicas o fisiológicas, abarcando la actividad fundamental de la célula, que a base de las características histológicas o puramente morfológicas.

(3) El hecho de que, en el hombre, haya frecuentes recurrencias de los tumores malignos en el quinquenio consecutivo a una

tanda de radioterapia, en particular en los jóvenes, parece corroborar el alcance de las observaciones realizadas en los tumores mamarios del ratón, por lo cual parecen hallarse indicados tratamientos de soporte antes de terminar el quinquenio.

DISCUSSION

B. V. A. Low-Beer, M.D. (San Francisco, Calif.): Dr. Goldfeder attempts in this study to throw light on the question as to why two analogous tumors of the same histologic structure, grown in the strains of mice in which they originated, differ so markedly in radiosensitivity.

The salient point of Dr. Goldfeder's paper is the suggestion that a more significant classification of tumors may be made on the basis of their biological characteristics rather than on the basis of histologic or purely morphologic characteristics. I agree with her that greater emphasis should be placed on the biological characteristics of a tumor than on the histologic appearance. The two tumors, although both were diagnosed microscopically as mammary carcinoma, differ greatly in their functional activity. The dba-strain tumor has secretory activity, while the C3H-strain tumor does not. This represents a great difference between the two tumors and explains, in my opinion, why their response to radiation differs.

Dr. Goldfeder suggests four points especially for discussion. First, the rate of growth and mitotic activity. I question whether the rate of macroscopic growth and/or mitotic activity considered in terms of relative numbers of metaphases, anaphases, and telophases is a reliable index for making predictions on tumor response to radiation.

The second point Dr. Goldfeder discussed was the metabolic activity of the tumor. The C3H tumor has a much lower oxygen uptake than the dba tumor, and also a much lower rate of aerobic glycolysis. Unfortunately no mention was made of changes in oxygen uptake and aerobic and anaerobic glycolysis after irradiation. In studies on Jensen's sarcoma in rats which I undertook some years ago, I was able to show that, after irradiation, oxygen consumption decreases by a factor of 4. Aerobic glycolysis, after an initial increase, decreases markedly. A notable increase of fermentation excess values was also demonstrated. Hevesy, in recent studies, showed impairment of phosphorylation in Jensen's sarcoma, following irradiation. Expansion of Dr. Goldfeder's studies in this direction might provide valuable clues to the question of radiation sensitivity of various tissues.

The third point concerns the difference in behavior observed in *in vitro* and *in vivo*. Dr. Goldfeder suggests that the increased rate of removal of toxic substances *in vivo* is due to a "wash-away effect." In tumors with greater secretory function this effect is, according to Dr. Goldfeder, naturally enhanced. This challenging hypothesis has certain elements of plausibility. It would seem, however, to require considerably more substantiation.

As to the fourth point, that of induced resistance following irradiation, Dr. Goldfeder suggests the development of an antimilk factor in the irradiated animals. This presupposes a relationship between the milk factor, considered as a virus, and the incidence of tumors. This argument in Dr. Goldfeder's study again rests on hypothesis only at the present time.

I hope that Dr. Goldfeder in her future work will pursue these important points further and provide us with more complete answers to these baffling problems.

Finally I wish to say that conditions of biological investigation are difficult to reproduce unless the physical factors are given with complete accuracy. I hope that Dr. Goldfeder will give us a more complete idea of the physical factors which she employed in these experiments when her present paper is published. This should include, I believe, the manner in which the animals were placed, whether the tumor bed or only the tumor was included in the radiation field, the size of field, and the tissue dose in preference to air dose.

EDITORIAL

The Pulmonary "Coin" Lesion

The widespread use of roentgenography of the chest as a detection agent in large series of normal or symptomless persons has inevitably raised problems both of diagnosis and management of the conditions thus disclosed. The solitary round, circumscribed, coin-like lesion is one that is frequently observed in the lungs of this asymptomatic group. With the multiplication of examinations we must expect the problem of its disposition to recur with increasing frequency. Shall we observe such lesions over varying periods of time or shall we advise surgical intervention for diagnostic and therapeutic considerations? This problem is of unusual interest to the radiologist, who will frequently be called upon for his opinion.

Due to the marked improvement in the general technic of chest surgery, with the consequent lowering of the mortality, removal of these pulmonary lesions is now commonplace in many medical centers. O'Brien, Tuttle, and Ferkaney (3) reported their results in a series of 21 cases in which lobectomy or pneumonectomy was performed. In no instance was the diagnosis definitely established prior to operation. Bronchogenic carcinoma was found in 8 (38 per cent) and tuberculoma in an equal number, abscess in 2 (9.5 per cent), sarcoma, cyst, and chondroma in 1 case each (4.9 per cent). There were no surgical deaths in this series. Six of the patients were asymptomatic. Cough was the commonest symptom but was not severe. Hemoptysis occurred in 4 cases. Bronchoscopic examination is often disappointing because these lesions occur in the lung periphery, but the cytologic study of bronchial washings gives promise of diagnostic aid.

In the report of 24 cases of solitary lung tumors, Effler, Blades, and Marks (1) present the final results of operative removal. Each of the lesions in this series was discovered during a routine roentgen examination of the chest, and in every instance was asymptomatic. Each case was carefully studied preoperatively by a variety of diagnostic methods, without establishment of a definite diagnosis. It is of interest that all were considered benign, though the final analysis showed 4 malignant tumors. The series included, also, 7 cysts, 8 tuberculomas, 3 benign tumors, and 2 diaphragmatic hernias. No deaths were recorded. Effler and his associates make the point that surgical care is often asked for pulmonary lesions producing serious symptoms, but that many physicians hesitate to consider the asymptomatic patient as a candidate for operation. That 15 per cent of these symptomless tumors proved to be malignant is regarded as justification for the surgical exploration of every solitary lesion of the lung.

Thoracotomy in 200 cases reported by Grow, Bradford, and Mahon (2) showed an over-all incidence of malignant tumors of 21.5 per cent. If only the intrapulmonary lesions are considered, the percentage rises to 25.6. This series was not confined to accidentally discovered asymptomatic lesions.

In the presence of a circumscribed coin-like pulmonary lesion where a final pathologic diagnosis has not been possible after all available diagnostic measures have been exhausted, several procedures are available. One may watch the lesion by serial roentgenograms, or give a "test-dose" of radiotherapy, or institute surgical exploration, with removal of the lesion.

Those who advocate watchful waiting

must assume the risk that the lesion may progress unfavorably. Tuberculomas are prone to enlarge and excavate. Certain benign tumors may become malignant. Malignant neoplasms may metastasize widely, though the primary tumor appears relatively unchanged. It should be remembered that evidence of growth does not necessarily denote malignancy, as nonmalignant tumors and inflammatory lesions may also enlarge.

A test-dose of radiotherapy will determine the radiosensitivity of the lesion but unfortunately will not provide clear-cut evidence of the histology, an important point in view of the statistics quoted above. Furthermore, it is the contention of many chest surgeons that extirpation of the lesion is increasingly difficult following radiotherapy, although the dosage employed plays a definite role in this respect.

There is a growing school of clinicians and surgeons who advocate the prompt removal of these obscure peripheral lesions. This view is supported by the low operative mortality, by the positive diagnosis thus afforded, and by the high rate of curability. These are potent reasons for the recommendation of surgical removal of lesions which have been shown to be potentially malignant in from 15 to 30 per cent of cases in the published series.

The radiologist's opinion and advice will continue to be influenced by the clinical findings in the individual patient rather than by dogmatic decisions, which are rarely applicable to a series of cases. Age is always an important consideration. In the statistics quoted above, the series showing the lowest percentage of malignancy—that of Effler, Blades, and Marks—was composed largely of young service personnel. The history, symptomatology, and physical findings will also play a part in all decisions regarding diagnosis and therapy. Beyond all these considerations, however, the radiologist must make the most careful analysis of the roentgen findings. The size and shape of the lesion, its location, the presence or absence of calcification and secondary lung changes, are of the utmost importance. In those cases where a diagnosis of an innocuous lesion cannot be reasonably established, the radiologist must take into account the low mortality of present-day chest surgery, the accuracy of the histologic diagnosis, and the possibility of complete removal of an early malignant growth.

REFERENCES

1 EFFLER, D. B., BLADES, B., AND MARKS, E.: Problem of the Solitary Lung Tumors. Surgery **24:** 917–928, December 1948.

2. GROW, J. B., BRADFORD, M. L., AND MAHON, H. W.: Exploratory Thoracotomy in the Management of Intrathoracic Disease. J. Thoracic Surg. **17:** 480–493, August 1948.

3. O'BRIEN, E. J., TUTTLE, WM. M., AND FERKANEY, J. E.: Management of the Pulmonary "Coin" Lesion. S. Clin. North America **28:** 1313–1322, October 1948.

ANNOUNCEMENTS AND BOOK REVIEWS

AMERICAN ROENTGEN RAY SOCIETY

At the Annual Meeting of the American Roentgen Ray Society in October, Dr. U. V. Portmann of Cleveland, Ohio, assumed office as President and Dr. Milton J. Geyman, of Santa Barbara, Calif., as Chairman of the Executive Council. Newly elected officers for 1949–50 are: President-Elect, B. P. Widmann, Philadelphia, Penna.; 1st Vice-President, A. E. Childe, Winnipeg, Manitoba; 2nd Vice-President, Robert C. Pendergrass, Americus, Ga.; Secretary, Barton R. Young, Philadelphia, Penna.; and Treasurer, Wendell G. Scott, St. Louis, Mo.

LOS ANGELES RADIOLOGICAL SOCIETY

The Second Annual Mid-Winter Radiological Conference sponsored by the Los Angeles Radiological Society will be held at the Biltmore Hotel, Saturday and Sunday, Feb. 25 and 26, 1950, with sessions from 10:15 to 4:15 on Saturday and from 9:30 to 3:00 on Sunday. At the banquet, at 7:00 P.M. on Saturday, Dr. Lowell S. Goin will act as master of ceremonies and Dr. Juan A. del Regato will be the speaker. Dr. del Regato's subject will be Transvaginal Roentgen Therapy for Carcinoma of the Cervix.

Others included on the two-day program are: Dr. William Costolow, Dr. George Griffith, Dr. Robert Pugh, Dr. Ray A. Carter, Dr. Gordon G. King, Dr. Marcy L. Sussman, Dr. Samuel Perzik, Dr. Ian Macdonald, Dr. Henry Kaplan, Dr. Earl R. Miller, and Dr. Henry C. Crozier.

The cost for the session is $15.00 and for the banquet $5.00. Reservations should be sent to Dr. Moris Horwitz, 441 North Camden Drive, Beverly Hills, Calif., accompanied by a check for $20.00. Hotel reservations may be made by applying directly to the convention manager of the Biltmore Hotel, Los Angeles. Early reservations are suggested, since accommodations are limited.

NORTH DAKOTA RADIOLOGICAL SOCIETY

At a recent meeting of the North Dakota Radiological Society the following officers were elected for 1950: President, Philip H. Woutat of Grand Forks; Vice-President, H. M. Berg of Bismarck; Secretary-Treasurer, Charles Heilman, 807 Broadway, Fargo.

The annual session will be held with the State Medical Society in May, at Grand Forks.

INTERNATIONAL AND FOURTH AMERICAN CONGRESS ON OBSTETRICS AND GYNECOLOGY

The International and Fourth American Congress on Obstetrics and Gynecology will meet in New York City May 14–19, 1950. The Chairman of the General Program Committee is Dr. Howard C. Taylor, Jr., and among the speakers listed to date are Prof. Heinrich Martius of the University of Göttingen; Dr. Leon Gerin-Lajoie of the University of Montreal; Dr. Carlos D. Guerrero of Mexico City; Dr. Arthur T. Hertig of Harvard Medical School; Dr. Carl Kaufmann of Phillip University, Marburg, Germany; Dr. Hans Ludvig Kottmeier of the Radiopathology Institute, Stockholm; Dr. Laksmanaswami Mudaliar of Madras University, India; Dr. Manuel Luis Peréz of Buenos Aires; S. R. M. Reynolds, Ph.D., of the Department of Embryology, Carnegie Institute; Dr. Walter Seegers of Wayne University College of Medicine, Detroit; Dr. Harold H. Sheehan of the School of Medicine of the University of Liverpool; Dr. Jean Snoek of the University of Brussels; Dr. Herbert F. Traut of the University of California Medical School.

Special programs are being arranged for nurses, public health workers, and hospital administrators.

Details as to registration, housing, and other matters may be obtained from Dr. Fred L. Adair, 161 East Erie St., Chicago 11, Ill.

UNITS OF RADIOACTIVITY

In November 1947, a joint committee of the Divisions of Chemistry and Chemical Technology and of Mathematical and Physical Sciences of the National Research Council was appointed to make recommendations regarding standards and units of radioactivity. This committee unanimously adopted the recommendations quoted below. The committee would like to point out that these recommendations effectively divorce the curie from the disintegration rate of radium by assigning to the former an arbitrary magnitude (3.7×10^{10} dis/sec) approximately equal to the disintegration rate of radium. This arbitrary figure is therefore not influenced by any future revisions of the generally accepted disintegration rate of radium. This recommendation has been submitted to the Joint Commission on Standards, Units, and Constants of Radioactivity of the International Unions of Chemistry and Physics for the purpose of obtaining international agreement.

This changes, slightly, the meaning of the curie when applied to radium. For example, 1 curie of radon is no longer, on the basis of these recommendations, the amount in equilibrium with 1 gram of radium, but is the amount undergoing 3.7×10^{10} disintegrations per second. Similarly, 1 mg. and 1 mc. of radium are no longer rigorously synonymous. This distinction has a number of precedents in physics; for example the international ampere, now abolished, was not quite equal to the absolute ampere, and the angstrom unit is nearly, but not quite, equal to 1,000 x-units.

"*Curie:* The curie should be defined as that quantity of any radioactive species (radioisotope) undergoing exactly 3.700×10^{10} disintegrations per second.

"*Rutherford:* The rutherford should be defined as that quantity of any radioactive species (radioisotope) undergoing 10^6 disintegrations per second.

"*Rhm:* For the quantitative comparison of radioactive sources emitting gamma rays, for which disintegration rates cannot be determined, the *roentgen per hour at one meter* (rhm) is recommended. This is not essentially a new unit since all units involved are well established, explicitly defined, and are in common usage."

The recommendation of this latter unit is a practical step to insure that, by its use, gamma ray measurements are so made with instruments and under such conditions that measurements on a given isotope (nuclear species) made in any laboratory will be directly comparable with similar measurements made in other laboratories. This will result, if the procedures used comply with the definition of the unit; that is, a source is 1 rhm if it produces 1 roentgen per hour at a distance of 1 meter.

L. F. CURTISS, *Chairman*
R. D. EVANS
WARREN JOHNSON
GLENN T. SEABORG

RADIOISOTOPES TECHNICS COURSES

Some vacancies still remain for the last two of the winter series of three Radioisotope Technics Courses offered by the Special Training Division of the Oak Ridge Institute of Nuclear Studies, announced in the November issue of RADIOLOGY.

Interested persons who can attend a course during the winter months are urged to make application for one of these courses in view of the heavy load of applications from university people for participation in the summer courses. The courses will begin on Jan. 30 and March 6, 1950. Requests for application and additional information should be addressed at once to Dr. Ralph T. Overman, Chairman, Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tennessee.

These courses are offered to acquaint research workers with the safe and efficient use of radioisotopes as tracers. Emphasis is placed on individual laboratory work, with sufficient lecture material included to provide the necessary background information.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

ROENTGEN DIAGNOSIS OF DISEASES OF THE SKULL. ANNALS OF ROENTGENOLOGY, VOL. 19. By MAX RITVO, M.D., Assistant Professor of Radiology, Harvard Medical School; Instructor in Radiology, Tufts Medical School, Boston, Mass., Director, Department of Radiology, Boston City Hospital; Associate in Radiology, Beth Israel Hospital, Boston. With a Foreword by GEORGE W. HOLMES, M.D. A volume of 410 pages, with 466 illustrations. Published by Paul B. Hoeber, Inc., New York, 1949. Price $16.00.

THE 1949 YEAR BOOK OF RADIOLOGY. Radiologic Diagnosis, edited by FRED JENNER HODGES, M.D., AND JOHN FLOYD HOLT, M.D. Radiation Therapy, edited by ISADORE LAMPE, M.D. A volume of 454 pages, with 393 illustrations. Published by the Year Book Publishers, Chicago, Ill. Price $6.50.

BONE AND JOINT RADIOLOGY. By EMERIK MARKOVITS, M.D., Formerly, Scientific Collaborator of the Central Radiologic Institute of the General Hospital (Holzknecht-Institute), Vienna; Head of the Radiologic Department of Elizabeth Hospital of the City of Budapest; Post-graduate Lecturer at the Central Radiologic Institute of the University of Budapest; Radiologist of the Steiner Cancer Clinic, Atlanta, Ga. A volume of 446 pages, with 616 illustrations. Published by The Macmillan Co., New York, 1949. Price $20.00.

X-RAY TREATMENT. ITS ORIGIN, BIRTH AND EARLY HISTORY. By EMIL H. GRUBBE, B.S., M.D., F.A.C.P., Charter Member and Emeritus Member of the Radiological Society of North America; Charter Member of the American Roentgen Ray Society; Diplomate of the American Board of Radiology; Associate Fellow of the American Medical Association; Emeritus Member of the Illinois State Medical Society; Member of the Chicago Medical Society. A volume of 154 pages, with 51 illustrations. Published by the Bruce Publishing Co., St. Paul, Minn., 1949. Price $3.00.

The MEDICAL ANNUAL. A YEAR BOOK OF TREATMENT AND PRACTITIONER'S INDEX. Editors: SIR HENRY TIDY, K.B.E., M.A., M.D. (Oxon), F.R.C.P., and A. RENDLE SHORT, M.D., B.S., B.Sc., F.R.C.S. A volume of 448 pages. Published by John Wright & Sons, Ltd., Bristol, and Simpkin Marshall (1941) Ltd., London, 1949.

MANUEL DE RADIODIAGNOSTIC CLINIQUE. By R. LEDOUX-LEBARD, Professor of Clinical Radiology of the Faculté de Médecine, Paris, and GUY-R. LEDOUX-LEBARD, Former Chief of the Clinic of the Faculté de Médecine, Paris. A volume of 1,408

pages, with 2,000 illustrations. Published by Masson et Cie, Paris, 2nd ed., completely revised, 1949.

DIE DYSTROPHIE. By PROFESSOR DR. MED. HEINRICH BERNING, I. Med. Universitätsklinik Hamburg-Eppendorf (Direktor Prof. H. H. Berg). A volume of 198 pages, with 34 illustrations and 15 tables. Published by Georg Thieme, Stuttgart, 1949. Distributed by Grune & Stratton, Inc., New York.

GRUNDLAGEN DER FUNKTIONELLEN UROLOGISCHEN RÖNTGENDIAGNOSTIK. By DR. MED. HABIL. WALTER PFEIFER, Sanderbusch. A volume of 88 pages, with 48 illustrations. Published by Georg Thieme, Stuttgart, 1949. Distributed by Grune & Stratton, Inc., New York.

AKTUELLE PROBLEME DER PATHOLOGIE UND THERAPIE. By PROFESSOR DR. H. HOLTHUSEN, Hamburg. A volume of 248 pages, with 49 illustrations. Published by Georg Thieme, Stuttgart, 1949. Distributed by Grune & Stratton, Inc., New York.

RÖNTGEN- UND RADIUMPHYSIK FÜR MEDIZINER. By DR. RICHARD GLOCKER, Professor of Roentgen Technic at the Technical School, Stuttgart. A volume of 276 pages, with 167 illustrations. Published by Georg Thieme, Stuttgart, 1949. Distributed in the United States by Grune & Stratton, Inc., New York.

SCHILDDRÜSE UND BASEDOW, BEITRÄGE ZUR HISTO-MORPHOLOGIE UND FUNKTION DER SCHILDDRÜSE VERSCHIEDENER FREILEBENDER TIERE. By PROF. WILHELM EICKHOFF, Rheine (Westfalen). A volume of 128 pages, with 42 illustrations. Published by Georg Thieme, Stuttgart, 1949. Distributed in the United States by Grune & Stratton, Inc., New York.

Book Reviews

A DESCRIPTIVE ATLAS OF RADIOGRAPHS. AN AID TO MODERN CLINICAL METHODS. By A. P. BERTWISTLE, M. B., Ch.B., F.R.C.S., Ed. A volume of 622 pages, with 980 illustrations. Seventh edition, revised and enlarged. Published by the C. V. Mosby Co., St. Louis, Mo., 1949. Price $16.00.

This is the seventh edition of an *Atlas* first published in 1926, with appropriate revisions and additions. In it the author attempts to demonstrate the possibilities of roentgen diagnosis. He addresses himself primarily to the clinician, so that the latter may know what x-rays are capable of revealing.

Several short introductory sections set forth some of the basic facts of radiology. These are followed by a section on "Milestones in Radio-Diagnosis," which seeks to outline the more important advances since the discovery of the roentgen ray. Because of the limited space, this inevitably falls far short of the mark, but nevertheless is a valuable guide. The bulk of the work is made up of reproductions of roentgenograms—the majority collected from the general infirmary at Leeds, others contributed by a number of British clinicians and radiologists—depicting normal and abnormal conditions in the various parts of the body. These are arranged according to systems, beginning with the skeletal system, to which nearly 150 pages are devoted. A few pages at the end of the volume are devoted to medicolegal problems, embryology, anthropology, helminthology, and occupational diseases. In many instances there is included a small pen-and-ink sketch graphically portraying the roentgen findings. Opposite each reproduction is a short case history, though frequently this does not fully describe the lesion. Many of the rarer conditions are omitted.

The volume is well bound and printed in large, clear type. An adequate index is appended. For the clinician whom the author had in mind, and for others who wish ready reference to roentgenograms of pathologic conditions, this work will prove useful.

ROENTGEN-RAY EXAMINATION OF THE DIGESTIVE TRACT. By ROSS GOLDEN, M.D., Professor of Radiology, The College of Physicians and Surgeons, Columbia University; Director of the Department of Radiologic Service, The Presbyterian Hospital, New York. Reprinted from Nelson's Loose-Leaf Diagnostic Roentgenology. A volume of approximately 250 pages, with 115 illustrations. Published by Thomas Nelson & Sons, New York, 1949. Price $5.00.

This volume is a reprint of a chapter by Dr. Golden appearing under the same title in Nelson's Loose-Leaf Diagnostic Roentgenology, with the addition of an index, which was badly needed in the original volume.

There are sections on the esophagus, stomach, duodenum, small intestine, large intestine, and gallbladder, together with a rather voluminous list of references. The descriptive matter pertaining to many of the lesions is comparatively brief and in some instances amounts essentially to a summary of the available information. The chapters on the stomach and small intestine, in particular, reflect the wide experience of the author. Numerous roentgenograms, photographs, and drawings illustrate the text.

Radiologists, students, and gastroenterologists will be happy to have in such handy, usable form, the material here presented.

MYELOGRAPHY WITH WATER-SOLUBLE CONTRAST, WITH SPECIAL REGARD TO THE NORMAL ROENTGEN PICTURE. Dissertation, Karolinska Institutet,

Stockholm. Acta Radiologica Supplementum 75. By SIGFRID ARNELL, Chief, Roentgenological Department, Larsarettet, Gävle. A monograph of 86 pages, with 61 illustrations. Published by Esselte Aktiebolag, Stockholm, 1949.

This 85-page dissertation offers a brief but adequate review of the subject of myelography, with special attention to the use of a water-soluble contrast medium for demonstration of the subarachnoid space.

The first chapter deals with the embryologic development of the spinal cord, its meninges, and the caudal part of the spinal canal. This is followed by a thorough consideration of the roentgen-anatomical picture of the subarachnoid space, more especially the lumbar area, illustrated with tables presenting measurements taken from postmortem roentgenograms of adults and children. Generous use is also made of roentgenographic reproductions to demonstrate the numerous variations that may occur in the normal arachnoid sac. To show the possibilities of detailed study of finer details, a section on arachnoiditis cystica et proliferans is included.

The final chapter is devoted to the actual myelographic procedure, including a skillfully condensed history of the search for an ideal contrast medium, the author's own early work with abrodil, and the technic of its present use for the demonstration of herniated disks.

While he admits that the ideal contrast medium for the examination of the subarachnoid space has not yet been found, the author's results with abrodil (sodium monoiodomethyl sulphonyl, JCH_2SO_3Na) have been such that he now uses it as the sole agent for myelographic studies. While not all radiologists will share his enthusiasm for this agent, they will find in this treatise an excellent review of the subject and a comprehensive list of references to the work of others.

ATOMIC MEDICINE. Edited by CHARLES F. BEHRENS, M.D., Captain, MC, U. S. Navy; Director, Atomic Defense Division, Bureau of Medicine and Surgery, Navy Department; Medical Officer in Command, Naval Medical Research Institute, National Medical Center, Bethesda, Md. A volume of 416 pages, with numerous illustrations. Published by Thomas Nelson & Sons, New York. 1949. Price $7.50.

The Preface to this volume bears the somewhat fanciful title "The Atom Knocks at the Doctor's Door," but the book itself is not fanciful. It is an excellent compendium of current knowledge of radiation as a disease-producing and therapeutic agent, the work of some score of contributors.

The discussion of nuclear physics is well done but does not entirely avoid the abstruseness apparently inherent in the subject. The use and effect of the atomic bomb are described in restrained language. A wealth of readily available data is found in such discussions as "The Pathologic Anatomy of Total Body Irradiation" and "The Hematology of Ionizing Radiation." The editor has contributed a useful chapter on dosage limits. Various theories of radiation sickness and specific therapeutic measures are critically summarized. There is also a well illustrated chapter on the detection and measurement of radiation. Description of the apparatus designed for acceleration of charged particles (cyclotron, etc.) has a tendency to excessive brevity.

About half the text is devoted to radioactive isotopes, their use in tracer studies, their value in therapy, and the physical plant required to use them.

Two appendixes are added, with definitions and other data for quick reference. Bibliographies are comprehensive, and illustrations are well selected.

The book is highly recommended.

RADIOLOGIA SCHERMOGRAFICA. By FRANCO FOSSATI, Professor of Radiology, University of Milan, and PATRIZIO GALLONE, Doctor of Physics. A volume of 388 pages, with 157 figures. Published by Garzanti, Milan, 1949.

This book is one of the most complete works on fluorophotography, covering practically all phases of the subject with the thoroughness of the old European school. It is so complete, in fact, that one may question the wisdom of including long chapters on the processing of the films and on the production of photographic images (43 pages). One hundred and fourteen pages are devoted to the history, apparatus, technic, and physics of fluorophotography, 52 pages to the optic systems, and appendixes cover a variety of subjects, including the voltage available in the Italian provinces and the use of logarithms in fluorophotography. Thirty-one pages are given to a five-language dictionary of fluorophotographic terms and 22 pages to the bibliography. A good index closes the book.

This work is well written, well illustrated, well printed, and is surprisingly easy to read considering the wealth of detail it covers. It may be an excellent source of reference for those interested in the fine points of fluorophotography.

IN MEMORIAM

William Herbert McGuffin, M.D.

1886–1949

Dr. William Herbert McGuffin, a past-president of the Radiological Society of North America, died suddenly in London, Ontario, Oct. 25, at the age of sixty-three. He was visiting his daughter and son-in-law on his return from Madison, Wisconsin, where he had been receiving medical treatment. He had been in failing health for the past several years.

"Herb" McGuffin was born in London, Ontario, the son of Elsie and William McGuffin. He was graduated in medicine from the University of Western Ontario in 1910 and commenced medical practice in Calgary, Alberta, the same year. Since 1918, he had confined his practice exclusively to radiology. During his early years in Calgary, he took special courses of instruction in radiology at the South Chicago Hospital, Cook County Hospital, Battle Creek Sanitarium, and Bellevue Hospital, New York. He was a great enthusiast, and his interest in his specialty was as keen the year of his death as it had been when he installed the first x-ray apparatus in his part of the country. He lived in and for his profession. In 1947, his practice in the Dr. W. H. McGuffin Radium and X-Ray Institute was taken over by his two younger partners, but he remained as an active consultant.

Dr. McGuffin was one of the founders of the Calgary Medical Society and took an active interest in its affairs until his death. He served as a Consultant Radiologist to the local military district during both World Wars and was a member of the Alberta United Services Institute. He was a Fellow of the American College of Radiology, diplomate of the American Board of Radiology and a Fellow of the United Empire Society. He was also a Fellow of the Faculty of Radiologists. He had served as President of the Radiological Society of North America, the Canadian Radiological Society, and the Canadian Association of Radiologists. In 1946, he was made Honorary Doctor of Laws at the University of Western Ontario.

With the late Dr. John McEachern, Dr. McGuffin organized the Alberta Cancer Society, later the Provincial Branch of the Canadian Cancer Society, of which he had been made an Honorary Life Member in 1949.

Dr. McGuffin's patients knew him as a friend, for he brought to his specialty a wealth of human understanding and experience. His clinical acumen and his judgment never failed, and he died while at the peak of his career. That is how he would have wished it.

J. J. PORTER, M.D.

William Herbert McGuffin, M.D.
1886–1949

RADIOLOGICAL SOCIETIES: SECRETARIES AND MEETING DATES

Editor's Note: Secretaries of state and local radiological societies are requested to co-operate in keeping this section up-to-date by notifying the editor promptly of changes in officers and meeting dates.

RADIOLOGICAL SOCIETY OF NORTH AMERICA. *Secretary-Treasurer*, Donald S. Childs, M.D., 713 E. Genesee St., Syracuse 2, N. Y.

AMERICAN RADIUM SOCIETY. *Secretary*, Hugh F. Hare, M.D., 605 Commonwealth Ave., Boston 15, Mass.

AMERICAN ROENTGEN RAY SOCIETY. *Secretary*, Barton R. Young, M.D., Philadelphia, Penna.

AMERICAN COLLEGE OF RADIOLOGY. *Secretary*, William C. Stronach, 20 N. Wacker Dr., Chicago 6, Ill.

SECTION ON RADIOLOGY, A. M. A. *Secretary*, Paul C. Hodges, M.D., 950 East 59th St., Chicago 37, Ill.

Alabama

ALABAMA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, W. D. Anderson, M.D., 420 10th St., Tuscaloosa.

Arizona

ARIZONA ASSOCIATION OF PATHOLOGISTS AND RADIOLOGISTS. *Secretary*, R. Lee Foster, M. D., 507 Professional Bldg., Phoenix.

Arkansas

ARKANSAS RADIOLOGICAL SOCIETY. *Secretary*, Fred Hames, M.D., Pine Bluff. Meets every three months and at meeting of State Medical Society.

California

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY. *Secretary*, Sydney F. Thomas, M.D., Palo Alto Clinic, Palo Alto.

EAST BAY ROENTGEN SOCIETY. *Secretary*, Dan Tucker, 434 30th St., Oakland 9. Meets monthly, first Thursday, at Peralta Hospital.

LOS ANGELES RADIOLOGICAL SOCIETY. *Secretary*, Wybren Hiemstra, 1414 S. Hope St. Meets monthly, second Wednesday, County Society Bldg.

NORTHERN CALIFORNIA RADIOLOGICAL CLUB. *Secretary*, Robert L. Ayers, M.D., 726 4th St., Marysville. Meets at dinner last Monday of September, November, January, March, and May.

PACIFIC ROENTGEN SOCIETY. *Secretary*, L. Henry Garland, M.D., 450 Sutter St., San Francisco 8. Meets annually with State Medical Association.

SAN DIEGO ROENTGEN SOCIETY. *Secretary*, R. F. Niehaus, M.D., 1831 Fourth Ave., San Diego. Meets first Wednesday of each month.

X-RAY STUDY CLUB OF SAN FRANCISCO. *Secretary*, Wm. F. Reynolds, M.D., University Hospital, San Francisco 22. Meets third Thursday at 7:45, January to June at Stanford University Hospital, July to December at San Francisco Hospital.

Colorado

COLORADO RADIOLOGICAL SOCIETY. *Secretary*, Paul E. RePass, M.D., 306 Republic Bldg., Denver 2. Meets monthly, third Friday, at University of Colorado Medical Center or Denver Athletic Club.

Connecticut

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary*, Fred Zaff, M.D., 135 Whitney Ave., New Haven. Meetings bimonthly, second Wednesday.

CONNECTICUT VALLEY RADIOLOGICAL SOCIETY. *Secretary*, Ellwood W. Godfrey, M.D., 1676 Boulevard, W. Hartford. Meets second Friday of October and April.

District of Columbia

RADIOLOGICAL SECTION, DISTRICT OF COLUMBIA MEDICAL SOCIETY. *Secretary*, Karl C. Corley, M.D., 1835 Eye St., N.W., Washington 6. Meets third Thursday, January, March, May, and October, at 8:00 P.M., in Medical Society Auditorium.

Florida

FLORIDA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John J. McGuire, M.D., 1117 N. Palafox, Pensacola. Meets in April and in November.

GREATER MIAMI RADIOLOGICAL SOCIETY. *Secretary*, David Kirsh, M.D., 712 duPont Bldg., Miami 32. Meets monthly, last Wednesday, 8:00 P.M.

Georgia

ATLANTA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Wm. W. Bryan, M.D., 490 Peachtree St., N.E. Meets second Friday, September to May.

GEORGIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Robert Drane, M.D., De Renne Apartments, Savannah. Meets in November and at the annual meeting of State Medical Association.

Illinois

CHICAGO ROENTGEN SOCIETY, *Secretary*, John H. Gilmore, M.D., 720 N. Michigan Ave., Chicago 11. Meets at the University Club, second Thursday of October, November, January, February, March, and April at 8:00 P.M.

ILLINOIS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly as announced.

ILLINOIS STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary*, Harold L. Shinall, M.D., St. Joseph's Hospital, Bloomington.

Indiana

INDIANA ROENTGEN SOCIETY. *Secretary-Treasurer*. William M. Loehr, M.D., 712 Hume-Mansur Bldg., Indianapolis 4. Annual meeting in May.

Iowa

IOWA X-RAY CLUB. *Secretary*, Arthur W. Erskine, M.D., 326 Higley Building, Cedar Rapids. Meets during annual session of State Medical Society.

Kansas

KANSAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Anthony F. Rossitto, M.D., Wichita Hospital, Wichita. Meets annually with State Medical Society.

Kentucky

LOUISVILLE RADIOLOGICAL SOCIETY, *Secretary-Treasurer*, Everett L. Pirkey, Louisville General Hospital, Louisville 2. Meets second Friday of each month at the Seelbach Hotel.

Louisiana

LOUISIANA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Johnson R. Anderson, M.D., No. Louisiana Sanitarium, Shreveport. Meets with State Medical Society.

ORLEANS PARISH RADIOLOGICAL SOCIETY. *Secretary*, Joseph V. Schlosser, M.D., Charity Hospital of Louisiana, New Orleans 13. Meets first Tuesday of each month.

SHREVEPORT RADIOLOGICAL CLUB. *Secretary*, Oscar O. Jones, M.D., 2622 Greenwood Road. Meets monthly September to May, third Wednesday.

Maryland

BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION. *Secretary*, J. Howard Franz, M.D., 1127 St. Paul St., Baltimore 2.

Michigan

DETROIT X-RAY AND RADIUM SOCIETY. *Secretary-Treasurer*, George Belanger, M.D., Harper Hospital, Detroit 1. Meetings first Thursday, October to May, at Wayne County Medical Society club rooms.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS. *Secretary-Treasurer*, R. B. MacDuff, M.D., 220 Genesee Bank Building, Flint 3.

Minnesota

MINNESOTA RADIOLOGICAL SOCIETY. *Secretary*, C. N. Borman, M.D., 802 Medical Arts Bldg., Minneapolis 2. Meets in Spring and Fall.

Missouri

RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY. *Secretary*, Wm. M. Kitchen, M.D., 1010 Rialto Building, Kansas City 6, Mo. Meetings last Friday of each month.

ST. LOUIS SOCIETY OF RADIOLOGISTS. *Secretary*, Charles J. Nolan, M.D., 737 University Club Bldg. Meets on fourth Wednesday, October to May.

Nebraska

NEBRASKA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Ralph C. Moore, M.D., Nebraska Methodist Hospital, Omaha 3. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

New England

NEW ENGLAND ROENTGEN RAY SOCIETY. *Secretary-Treasurer*, George Levene, M.D., Massachusetts Memorial Hospitals, Boston. Meets monthly on third Friday at the Harvard Club.

New Hampshire

NEW HAMPSHIRE ROENTGEN SOCIETY. *Secretary*, Albert C. Johnston, M.D., Elliot Community Hospital, Keene. Meetings quarterly in Concord.

New Jersey

RADIOLOGICAL SOCIETY OF NEW JERSEY. *Secretary*, Benjamin Copleman, M.D., 280 Hobart St., Perth Amboy. Meets at Atlantic City at time of State Medical Society and midwinter in Elizabeth.

New York

ASSOCIATED RADIOLOGISTS OF NEW YORK, INC. *Secretary*, William J. Francis, M.D., East Rockaway.

BROOKLYN ROENTGEN RAY SOCIETY. *Secretary*, J. Daversa, M.D., 603 Fourth Ave., Brooklyn. Meets fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*. Mario C. Gian, M.D., 610 Niagara St., Buffalo 1. Meetings second Monday, October to May.

CENTRAL NEW YORK ROENTGEN SOCIETY. *Secretary*, Dwight V. Needham, M.D., 608 E. Genesee St., Syracuse 10. Meetings January, May, October.

KINGS COUNTY RADIOLOGICAL SOCIETY. *Secretary*, Marcus Wiener, M.D., 1430 48th St., Brooklyn 19. Meetings fourth Thursday evening, October to May, at 8:45 P.M., in Kings County Medical Bldg.

NEW YORK ROENTGEN SOCIETY. *Secretary*, F. H. Ghiselin, M.D., 111 E. 76 St., New York.

QUEENS ROENTGEN RAY SOCIETY. *Secretary*, Jacob E. Goldstein, M.D., 88-29 163rd St., Jamaica 3. Meets fourth Monday of each month.

ROCHESTER ROENTGEN-RAY SOCIETY. *Secretary-Treasurer*, Ralph E. Alexander, M.D., 101 Medical Arts Bldg., Rochester 7. Meets at Strong Memorial Hospital, third Monday, September through May.

North Carolina

RADIOLOGICAL SOCIETY OF NORTH CAROLINA. *Secretary*, James E. Hemphill, M.D , Professional Bldg., Charlotte 2. Meets in May and October.

North Dakota

NORTH DAKOTA RADIOLOGICAL SOCIETY. *Secretary*, Charles Heilman, M.D., 807 Broadway, Fargo.

Ohio

OHIO STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Edward C. Elsey, M.D., 927 Carew Tower, Cincinnati 2. Meets with State Medical Association.

CENTRAL OHIO RADIOLOGICAL SOCIETY. *Secretary*, Paul D. Meyer, M.D., Grant Hospital, Columbus. Meets second Thursday, October, December, February, April, and June, 6:30 P.M., Seneca Hotel, Columbus.

CINCINNATI RADIOLOGICAL SOCIETY. *Secretary*, E. C. Elsey, M.D. Meets last Monday, September to May.

CLEVELAND RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John R. Hannan, M.D., Cleveland Clinic, Cleveland 6. Meetings at 6:30 P.M. on fourth Monday, October to April, inclusive.

Oklahoma

OKLAHOMA STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, W. E. Brown, M.D., 21st and Xanthus, Tulsa 4. Meets in October, January, and May.

Oregon

OREGON RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Selma Hyman, M.D., University of Oregon Medical School, Portland. Meets monthly, on the second Wednesday, at 8:00 P.M., in the library of the University of Oregon Medical School.

Pacific Northwest

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Sydney J. Hawley, M.D., 1320 Madison St., Seattle 4. Meets annually in May.

Pennsylvania

PENNSYLVANIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, James M. Converse, M.D., 416 Pine St., Williamsport 8. Meets annually.

PHILADELPHIA ROENTGEN RAY SOCIETY. *Secretary*, George P. Keefer, M.D., 1930 Chestnut St., Philadelphia 9. Meets first Thursday of each month at 8:00 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22nd St.

PITTSBURGH ROENTGEN SOCIETY. *Secretary-Treasurer*, Edwin J. Euphrat, M.D., 3500 Fifth Ave., Pittsburgh 13. Meets second Wednesday of each month at 6:30 P.M., October to May, at Webster Hall.

Rocky Mountain States

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Maurice D. Frazer, M.D., Lincoln Clinic, Lincoln, Nebr.

South Carolina

SOUTH CAROLINA X-RAY SOCIETY. *Secretary-Treasurer*, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston 16.

South Dakota

RADIOLOGICAL SOCIETY OF SOUTH DAKOTA. *Secretary-Treasurer*, Marianne Wallis, M.D., 1200 E. Fifth Ave., Mitchell. Meets during Annual Session of State Medical Society.

Tennessee

MEMPHIS ROENTGEN CLUB. Meetings second Tuesday of each month at University Center.

TENNESSEE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Marsh Frére, M.D., 707 Walnut St., Chattanooga. Meets annually with State Medical Society in April.

Texas

DALLAS-FORT WORTH ROENTGEN STUDY CLUB. *Secretary*, X. R. Hyde, M.D., Medical Arts Bldg., Fort Worth 2. Meets monthly, third Monday, in Dallas odd months, Fort Worth even months.

HOUSTON X-RAY CLUB. *Secretary*, Curtis H. Burge, M.D., 3020 San Jacinto, Houston 4. Meetings fourth Monday of each month.

TEXAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, R. P. O'Bannon, M.D., 650 Fifth Ave., Fort Worth. Next meeting Feb. 3–4, 1950, in Dallas.

Utah

UTAH STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Angus K. Wilson, M.D., 343 S. Main St., Salt Lake City. Meets third Wednesday, January, March, May, September, November.

Virginia

VIRGINIA RADIOLOGICAL SOCIETY. *Secretary*, P. B. Parsons, M.D., Norfolk General Hospital, Norfolk 7.

Washington

WASHINGTON STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John H. Walker, M.D., 1115 Terry Ave., Seattle. Meetings fourth Monday, October through May, at College Club, Seattle.

Wisconsin

MILWAUKEE ROENTGEN RAY SOCIETY. *Secretary-Treasurer*, Theodore J. Pfeffer, M.D., 839 N. Marshall St., Milwaukee 2. Meets monthly on second Monday at the University Club.

RADIOLOGICAL SECTION OF THE WISCONSIN STATE MEDICAL SOCIETY. *Secretary*, Abraham Melamed, M.D., 425 E. Wisconsin Ave., Milwaukee. Two-day meeting in May; one-day with State Medical Society, September.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE. Meets first and third Thursdays 4 P.M., September to May, Service Memorial Institute, Madison 6.

WISCONSIN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Irving I. Cowan, M.D., 425 East Wisconsin Ave., Milwaukee 2.

Puerto Rico

ASOCIACIÓN PUERTORRIQUEÑA DE RADIOLOGÍA. *Secretary*, Jesús Rivera Otero, M.D., Box 3542, Santurce, Puerto Rico.

CANADA

CANADIAN ASSOCIATION OF RADIOLOGISTS. *Honorary Secretary-Treasurer*, E. M. Crawford, M.D. Associate Honorary Secretary-Treasurer, Jean Bouchard, M.D. *Central Office*, 1535 Sherbrooke St., West, Montreal 26, Quebec. Meetings in January and June.

LA SOCIÉTÉ CANADIENNE-FRANÇAISE D'ELECTROLOGIE ET DE RADIOLOGIE MÉDICALES. *General Secretary*, Origéne Dufresne, M.D., Institut du Radium, Montreal. Meets third Saturday each month.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA. Offices in Hospital Mercedes, Havana. Meets monthly.

MEXICO

SOCIEDAD MEXICANA DE RADIOLOGÍA Y FISIOTERAPIA. *General Secretary*, Dr. Dionisio Pérez Cosío, Marsella 11, México, D. F. Meetings first Monday of each month.

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Some Aspects on the Technique of Encephalography. E. Lindgren. Acta radiol. **31:** 161–177, Feb. 28, 1949.

The author discusses the various methods of performing encephalography, and describes his procedure, as used at the Seraphimer Hospital, Stockholm.

The patient is seated at a vertically placed Lysholm skull-table with the head slightly flexed. Generally lumbar puncture is used. A few c.c. of spinal fluid are removed to ascertain that the needle is properly placed, and 5 c.c. of air are then slowly injected. Following the removal of an additional amount of fluid, a further amount of 5 c.c. of air is introduced and a film is taken. After withdrawing a total amount of 8 c.c. of fluid, another view is obtained, which is eventually supplemented by a frontal view produced by rotating the roentgen tube without altering the posture of the head. These views are examined before any more air is injected. If the position of the head is such that the fourth ventricle and the aqueduct are brought forward in these views, this is evidence that air is entering, and another 5 c.c. can be introduced into the ventricular system. Unless the ventricular system is dilated, no more air is required. If more air is introduced, this quantity is moved into the cisterns and on to the convexity. Total air used is 20–25 c.c.

If air is present dorsal to the cerebellum, the degree of flexion is too sharp and should be reduced. If air lies in the cisterna pontis, the head has not been flexed enough. A further amount of 5 c.c. of air has to be injected and another view produced.

Before the films are examined, some information as to the route taken by the air can be obtained. If the patient has no sensations in the head following 10 c.c. of air, this is a sign that the air is entering the ventricular system. If air passes to the convexity, some headache is immediately experienced. A sense of pressure but no headache may be felt if air enters the ventricular system before a corresponding amount of fluid is removed.

When cisternal puncture is used, the position of the head for the puncture is approximately correct for air injection. Slow injection is made to fill the ventricular system; fast injection is made to fill the cisterns.

It is always hazardous to indicate the degree of accuracy obtained by any encephalographic method because many factors influence the result. Out of 152 lumbar encephalograms obtained by the method described; 142 were satisfactory with respect to the air filling; in 19 of these encephalography had been attempted elsewhere, with no filling of the ventricular system.

Thirty-one roentgenograms. E. H. Bryson, M.D.
Cleveland Clinic Foundation

Diagnosis of Chronic Subdural Haematoma in Children and Adolescents. J. W. D. Bull. Brit. J. Radiol. **22:** 68–80, February 1949.

Fifteen cases of subdural hematoma or hygroma in patients ranging in age from one to twenty years are described. The roentgen signs were pathognomonic in 12 cases and the diagnosis was confirmed at operation in 13.

The cases can be classified into three groups: (1) those in which the ordinary roentgen examination is negative but the pneumographic picture is characteristic (3 cases); (2) those in which ordinary roentgenograms show changes which are pathognomonic (9 cases); (3) cases with calcified hematomas and hemiatrophy of the affected side of the skull (3 cases).

Diagnostic interest centers chiefly in the cases in the second group. These all showed the same changes, namely: elevation of the lesser wing of the sphenoid, bulging of the greater wing, and forward bulging of the middle fossa. These changes are sufficient for a diagnosis.

Two views, carefully taken, are particularly important. A postero-anterior with the central ray directed caudad and at an angle of 20 degrees to the base of the skull throws the shadow of the lesser sphenoid wing into the orbits and shows clearly any elevation. A submentovertical view with the central ray perpendicular to the base shows clearly the bulging of the greater wing and the middle fossa. Lateral views are of only limited value, for, unless they are true laterals, deceptive distortions will occur.

The changes described were discovered in one case three months after head injury. They have been said to occur as early as six weeks after trauma.

The cases in the third group presented no difficulties in diagnosis. They were all of long standing with the hematoma calcified or ossified and hemiatrophy of the affected side.

Twenty-one roentgenograms; 8 drawings; 2 tables.
Sydney J. Hawley, M.D.
Seattle, Wash.

Case of Amyotonia Congenita Associated with Occlusion of the Sagittal Sinus and Bilateral Subdural Hygroma. Demonstration of Occlusion by Diotrast Sinography. Michael Scott. J. Pediat. **34:** 181–194, February 1949.

In amyotonia congenita there is a marked degree of muscular flaccidity producing an extensive range of passive movement of all joints. The muscles are flabby but not atrophic. Active movement is decreased and tendon reflexes are diminished or absent. Whether the pathologic changes lie in the nervous system or in the muscles is a matter of controversy. Scott reports the present case in the hope that it may suggest the etiology in some patients.

At the age of seven months a child was brought in by his mother because he did not move his legs. The family history was negative. The mother's obstetrical history was significant only in that she had sustained a fall during the 8th month and her observation that "this baby did not move in my abdomen like my previously normal child."

Neurological findings were as follows: enlarged head in the parietal areas, with a large anterior fontanelle; weakness on smiling, more marked on the left; absence of reflexes; marked hypotonia, so that the infant could not hold up his head or move his extremities. Routine laboratory studies were not significant. Muscle biopsies were compatible with the diagnosis of amyotonia congenita.

Encephalography demonstrated a communicating hydrocephalus and moderate brain atrophy. Diodrast injection into the sagittal sinus at the anterior fontanelle

showed it to be blocked posteriorly. A similar film taken on another case without obstruction is supplied for comparison.

Seven excellent roentgenograms; 3 photomicrographs; 2 photographs. STANLEY H. MACHT, M.D.
Baltimore (Md.) City Hospitals

Roentgen Examination of the Larynx of Children Suffering from False Croup. Sven Roland Kjellberg. Acta radiol. **31:** 127–128, Feb. 28, 1949.

The author describes the differential examination of children who suddenly exhibit paroxysms of coughing and difficulty in breathing. These attacks may awaken the child from a peaceful sleep but, nevertheless, suggest the presence of a foreign body. Opaque foreign material may be excluded easily by roentgenograms but non-opaque objects present more of a diagnostic problem. When such foreign bodies are excluded, the possibility of false croup is suggested.

Children suffering from false croup have edema of the labium vocale, which is the attached fleshy portion of the true vocal cords. This edema presents below the cords and causes the previously described symptoms by partial occlusion of the subglottic airway. Narrowing of the trachea in this region can be demonstrated roentgenographically. An anteroposterior exposure at no more than 0.03 second, is recommended. The neck should be extended for the examination by putting a pillow under the child's shoulders. The edema apparently responds to medical management; three films of one case are reproduced, showing beginning regression at the end of three days. A. A. RAYLE, JR., M.D.
Cleveland Clinic Foundation

THE CHEST

Importance of Exploratory Thoracotomy in the Diagnosis of Certain Pulmonary Lesions. Clive R. Johnson, O. Theron Clagett, and C. Allen Good. Surgery **25:** 218–230, February 1949.

This article analyzes the authors' experience with 384 patients operated upon between Jan. 1, 1942, and April 7, 1947, for lesions involving the lungs. In 270 a diagnosis was made on the basis of the clinical records, laboratory findings, and other non-surgical diagnostic aids. In 114 cases exploratory thoracotomy was necessary. Since in 3 instances the diagnosis was indefinite even after exploration, 111 cases remain for analysis. In every instance an effort was made to establish a preoperative diagnosis by standard methods, including bronchography, laminagraphy, bronchoscopic study when the lesion was in an available part of the lung, skin tests, sputum studies, and in some cases examination of bronchial secretions for malignant cells, though this last test had not at the time reached its present stage of efficiency. The cases form three groups:

(1) Mass lesions, numbering 53, constituted the largest group for which exploratory thoracotomy was performed. Ninety per cent of these lesions appeared to be located in the peripheral portions of the pulmonary field. Slightly more than one half were in the upper lobe. Changes secondary to bronchial obstruction appeared with 5 of these mass lesions. It was impossible to establish a definite criterion which would distinguish one type of lesion from another. In fact, a striking similarity was noted in the roentgenographic appearance of various types of benign and malignant lesions, though the benign lesions tended to be more sharply circumscribed. Seventy-four per cent of the lesions proved at operation to be malignant. It is the authors' conviction that indeterminate mass lesions in the lung deserve immediate exploratory thoracotomy.

(2) Lesions producing bronchial obstruction were accompanied by symptoms of pulmonary disease in all patients. X-ray examination demonstrated some degree of atelectasis in more than one half of these cases; in the rest the lesion was described as inflammatory, infiltrative, cavitating, or consolidative. An underlying malignant growth was found at operation in 50 per cent of the 48 cases in which the bronchoscopic and roentgen evidence of disease was only that of bronchial obstruction, though the presence of a malignant lesion had been suspected in many of the cases.

(3) In 10 cases neither an obstructive lesion nor a mass could be definitely demonstrated. In 2 instances a carcinoma was found; in 3 bronchial adenoma; in 3 suppuration and abscess; in 1 lipoid pneumonitis; and in 1 a silicotic stricture of the bronchus. The authors feel that all of these lesions could be treated most effectively by pulmonary resection.

It is obvious that if the patients whose lesions were represented primarily by changes secondary to bronchial obstruction had been seen earlier, some would have presented mass lesions. This would certainly be true of many with bronchogenic carcinoma. The time at which the effect of an obstructing lesion in a bronchus becomes evident depends, of course, upon the location and character of the lesion. Eleven, or 28 per cent, of the 39 malignant lesions in Group I were found inoperable, whereas 46 per cent of the 24 malignant lesions in Group II were inoperable.

The roentgenogram of the thorax remains as the most important single procedure for detecting the presence of a pulmonary lesion, though it cannot be too strongly emphasized that the roentgenogram is not a means of exact diagnosis. If the presence of a serious lesion can be suggested by roentgenography, then the maximal benefit to the patient from this procedure will have been realized. Other measures can then be taken in proper sequence for the establishment of a final diagnosis. It is important to mention that a bronchogenic carcinoma may be demonstrated occasionally in spite of a normal roentgenogram. Other lesions, as bronchiectasis and bronchial adenoma, are similarly found. Substantiation of the presence of these diseases rests upon bronchographic or bronchoscopic study.

A period of observation must be classed as a diagnostic aid and has its place in the sequence of diagnostic events. This period, however, should not be longer than four weeks in most cases, in which time a simple inflammatory process would be expected to subside. In the group of indeterminate lesions it was impossible, in some cases, to determine by means of inspection and palpation alone at operation whether the lesion was benign or malignant. In such instances it was usually possible to perform a segmental excision or a lobectomy as an initial procedure, with further surgery depending upon the pathologist's report. Any operative procedure must be judged in the light of what it accomplishes and the mortality. There were no deaths among the 25 patients who underwent exploration only. Six deaths followed pneumonectomy and two followed lobectomy.

Nineteen roentgenograms; 7 tables.
JOHN E. WHITELEATHER, M.D.
Memphis, Tenn.

Respiratory Emergencies in the Newborn. Willard F. Goff. West. J. Surg. **57:** 49–57, February 1949.

Atelectasis is the most common cause of respiratory difficulty in the newborn and may result from failure of expansion of the lungs or obstruction of a bronchus by aspirated mucus. The author condemns the use of positive-negative pressure machines and other forceful means in such cases and recommends pure oxygen given by open mask or pressure cone and thorough aspiration of mucus from the respiratory tract. The various drugs which have been used to stimulate respiration, as coramine, caffeine, alpha-lobeline, adrenalin and whisky, are considered of little or no value. Carbogen is not necessary, since atelectatic infants already have an excess of carbon dioxide in the blood.

Respiratory emergencies may also arise as a result of pneumothorax, with and without rib fractures [fortunately rare]; esophageal atresia, usually accompanied by a tracheo-esophageal fistula; diaphragmatic hernia; lung cysts; and thymic enlargement [not usually seen in the first few weeks]. A number of congenital abnormalities of the larynx can cause respiratory distress, but are less common than the chest conditions.

It is concluded that a direct laryngoscopy should be done in every newborn infant who fails to start respirations promptly or who shows evidence of respiratory distress. In the presence of cyanosis, three anteroposterior chest films should be obtained to aid in the differential diagnosis of pulmonary, cardiac, and cerebral disease.

Representative cases are presented. An emergency infant resuscitator outfit for use in the delivery room is described.

Twenty-five illustrations, including 21 roentgenograms; 1 chart. ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Limitations of the Role of the Radiologist in the Diagnosis of Pulmonary Tuberculosis. Keith H. Hallam. M. J. Australia **1:** 193–195, Feb. 12, 1949.

Although the use of x-rays in the detection of tuberculosis is unlimited, the role of the radiologist in this respect has its limitations. He must select, without any clinical background, with no histories, examinations, or consultations, the films which indicate that the patient is suffering with this disease. It is to be remembered always that miniature films should be read only as negative or positive as regards tuberculosis, the details not to be filled in until a large film has been seen. Even in the study of large films the radiologist may find his scope limited by lack of clinical information. Further limitations exist in the variations of exposure factors and the technic of processing, which can affect the quality of the film or produce misleading artefacts, and in the human element. To illustrate this latter feature, the author cites American experience, which showed that not only may radiologists differ among themselves as to interpretation of a film, but that the same radiologist may read a film as negative on one occasion and positive on another [see Garland: Radiology **52:** 309, 1949].

The ideal situation exists when the radiologist reads films in association with the clinician, with the aid of a good history and a good summary of the clinical findings. Thus he becomes a consulting, co-ordinating physician. ZAC F. ENDRESS, M.D.
Pontiac, Mich.

X-Ray Interpretation of Pulmonary Tuberculosis in Childhood. Colin Macdonald. M. J. Australia **1:** 200–203, Feb. 12, 1949.

Diagnosis of childhood tuberculosis depends chiefly on three examinations: skin testing, bacteriological study, and the roentgen examination. None of these is sufficient in itself.

The x-ray evidence of tuberculosis in the child concerns the primary focus and its perifocal exudate, the lymphangitis, lymph node enlargement, and pleural effusion. Many variations of the classical picture are seen. The primary focus is usually in a lower lobe, but it may be in any portion of either lung. If it is small, with little perifocal reaction, it may escape detection on the film, and there may be no sign of even larger foci until they become evident by virtue of calcification. Lymphangitis, or perilymphatic infiltration, is seen only when the primary focus is large; it is demonstrable as an increased density of the linear markings extending from the primary focus to the enlarged hilar nodes. Some evidence of pleural reaction, often minimal, is seen fairly often in childhood infection. Effusion is uncommon under the age of two years, in the author's experience.

The question of lymph node involvement is a difficult one unless the enlargement is unequivocal. To be plainly seen, the nodes must be very large. Such enlargement may increase the size of the hilar and cardiovascular shadows, but the wide normal variations in these must be taken into consideration. The hilar shadows are influenced also by the phase of respiration, the degree of rotation, and the target-film distance. If the tracheobronchial group of nodes is involved, the diagnosis becomes easier because of their position above the hilus.

The author has usually regarded calcification either in the lung parenchyma or the hilar nodes as representing tuberculosis, though it is known that it may be associated with other conditions, as histoplasmosis, aspergillosis, and coccidioidomycosis.

Cavitation may occur [though it is relatively rare in childhood]. It may be simulated by a circumferential pattern of infiltration or may be obscured by overlying and surrounding disease. Miliary spread [fortunately relatively rare] may elude detection in its early stage. Obstructive emphysema and atelectasis from pressure of the enlarged nodes on the larger bronchi are also seen. At least part of the picture called "epituberculosis" is thought to be this type of atelectasis.

The author concludes with a review of the details of technic, with emphasis on the difficulties encountered in these active, often unco-operative patients.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Radiological Interpretation and Pulmonary Tuberculosis in the Adult. R. M. de Lambert. M. J. Australia **1:** 203–206, Feb. 12, 1949.

Pulmonary tuberculosis in the adult produces an infinite variety of radiographic appearances. The location and extent of the pathological process can in most instances be accurately defined, though special views and technics are often necessary. The character of the process can also often be inferred from the roentgen picture. Consolidation, hyperemia, atelectasis, emphysema, fibrosis, and calcification all present more or less characteristic appearances. Cavitation may be de-

monstrable in routine views but may require a special technic, as tomography. Tomography also permits study of the main subdivisions of the bronchial tree.

The observation of the progress of the disease following its disovery is perhaps, with the initial observation of the lesion, the most valuable application of radiology to adult tuberculosis. For this purpose technic is all-important, with exact duplication of the radiographic quality at successive examinations.

The author stresses the importance of an understanding of the way in which radiographic images are formed and a thorough knowledge of the pathology of tuberculosis as an aid in film interpretation, and especially in the follow-up of individual cases. He calls attention also to recent technical advances which may lead to revolutionary changes in the application of radiology to the chest. ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Pulmonary Tuberculosis in the Elderly. Keith H. Hallam. M. J. Australia **1:** 206–207, Feb. 12, 1949.

A miniature film survey in Adelaide, Australia, showed a possible 6 per cent incidence of tuberculosis of all types in patients over forty-five years of age. The number of active cases is not stated.

Although elderly patients do have a certain amount of native and acquired resistance to tuberculosis, there is also to be considered the decrease in their general resistance and the presence of other disease processes. At times some other disease will cause a quiescent tuberculous lesion to become active and even go on to a miliary spread. The dangerous cases from the public health standpoint are those with chronic open disease which remains undiscovered for lack of serious symptoms.

Autopsy statistics from a general hospital showed an incidence of tuberculosis of 3.8 per cent over the age of fifty. In view of such findings, a plea is made for mass radiography of the aged, at least of those admitted to hospitals and other institutions.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Tomography as an Aid in the Diagnosis and Treatment of Pulmonary Tuberculosis. Alan King. M. J. Australia **1:** 207–208, Feb. 12, 1949.

Tomography is of definite help in several situations encountered in tuberculosis. Apical cavities are well shown by this method when conventional films fail because of the overlying ribs and clavicle. Cavities are better shown in the midst of fibrosis or after thoracoplasty has been performed or where there is extensive pleural thickening. The tracheobronchial tree is also more clearly demonstrated by this method, revealing strictures and displacements.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Value of Roentgenology in the Prognosis of Minimal Tuberculosis. Archibald L. Cochrane, Harold W. Campbell, and Samuel C. Stein. Am. J. Roentgenol. **61:** 153–165, February 1949.

This paper is the first of a series which will deal with minimal pulmonary tuberculosis on a statistical basis. The purpose of this initial communication is to evaluate the prognostic value of roentgenology in minimal pulmonary tuberculosis and to determine the outcome of cases diagnosed by the roentgenologist as active, or of questionable clinical significance, or inactive (of no clinical significance).

The study is based upon the initial roentgenograms of 1,100 patients with minimal pulmonary tuberculosis diagnosed in the chest clinic of the Henry Phipps Institute, University of Pennsylvania, from 1926 to 1945. The follow-up period ranged from one month to nineteen years.

The authors' statistical analyses are based on a formula from which two rates were calculated per 100 person years of observation: the progression rate, *i.e.*, the number of cases of minimal tuberculosis which progressed to the moderately advanced stage, and the death rate. Thirteen tables and 2 figures are presented, indicating that there is a considerable roentgenological error in determining the prognosis of a minimal pulmonary tuberculosis lesion at the time of the first roentgenogram.

[This is an abstruse paper from the point of view of a roentgenologist. It is difficult to follow the statistical analysis whereby the authors arrive at their conclusions.] SAMUEL MORCHAN, M.D.
Indiana University

Is Tuberculosis Contagious? Should Radiophotography Be Obligatory? O. M. Mistal. Schweiz. med. Wchnschr. **79:** 119–120, Feb. 12, 1949. (In French)

Mistal presents his arguments for a compulsory photoroentgen survey of the entire Swiss population in refutation to the ideas of Champod [reference not given], who apparently opposes this idea. The passage of such a law is under consideration, and the author believes that the cost is not prohibitive [although he seems to consider only the film cost], that the inconvenience is not excessive, and that administration is possible. He suggests a three-yearly examination, with isolation of the cases discovered to protect the young from exposure. LEWIS G. JACOBS, M.D.
Oakland, Calif.

An Appraisal of the Results of a Six-Year Tuberculin and Mass X-Ray Survey of the Population of Asunción: Based on More than 100,000 Tests. Angel R. Gines, Eduardo Gould, and J. A. Coronel Vera. Dis. of Chest **15:** 142–161, February 1949.

The authors report a mass survey in Asunción, Paraguay, including roentgenography, tuberculin tests, BCG vaccination, repeat examinations, and laboratory tests, and give the results of observations for 1941 to 1946, inclusive. The survey involved a population of 126,000, for some 75,000 or 80,000 of which microfilms were obtained. It is concluded that tuberculosis case finding can be accomplished by mass survey of communities, examination of the families and known contacts of tuberculous persons, and all hospital admissions.

Two graphs; 8 tables. HENRY K. TAYLOR, M.D.
New York, N. Y.

Streptomycin-Tuberculosis Research Project of the American Trudeau Society. A Summary Report. H. McLeod Riggins and H. Corwin Hinshaw. Am. Rev. Tuberc. **59:** 140–167, February 1949.

The present communication is a preliminary report by a group of co-operating investigators appointed by the American Trudeau Society to study the therapeutic

effects of streptomycin on pulmonary tuberculosis. A more comprehensive report is to be published later in book form.

A total of 566 patients were studied between September 1946 and January 1948. A statistical analysis was carried out on the pertinent findings in 332 patients who had completed streptomycin therapy and had been observed for at least ninety days after the beginning of treatment. The remaining 234 patients are not included in the present analysis. The material is summarized as follows:

1. As reported by others, the degree of efficacy of streptomycin is definitely related to the *character* of the pulmonary disease.
2. Although improvement occurred more frequently and was more marked in patients with predominantly acute disease, most of the investigators reported significant improvement in a small percentage of patients with chronic disease.
3. Since progression of chronic tuberculosis is fundamentally related to the occurrence of acute episodes, the great potentialities of the strategic use of short courses of streptomycin to combat such episodes is stressed.
4. The larger daily doses appeared to bring about more frequent and more marked improvement than the smaller daily doses.
5. The occurrence of drug-fast organisms was definitely related to the duration of treatment.
6. The failure to convert sputum and closed cavities in a large percentage of patients and the relapse of the disease with passage of time emphasize the limitations of antibacterial therapy and the necessity of also using more definitive treatment, notably collapse therapy, if lasting results are to be achieved.

Ten graphs and tables.

L. W. PAUL, M.D.
University of Wisconsin

Treatment of Acute Putrid Lung Abscess with Penicillin and Sulfadiazine. Barnet P. Stivelman and Julius Kavee. Ann. Int. Med. **30:** 343–363, February 1949.

Acute putrid lung abscess is one of the most serious of intrathoracic diseases. It may lead to an early fatal termination due to toxemia, hemoptysis, embolic phenomena, spill-over to the contralateral lung and rupture into the pleura. Or if an early fatal issue does not ensue, the acute abscess becomes chronic, requiring extensive and difficult surgical intervention and, at best, a prolonged and costly convalescence. At the Harlem Hospital, New York, in the past few years spontaneous recoveries were noted in only 11 per cent of 70 patients with this disease.

When penicillin became freely available, it was decided to study its potentialities in the treatment of putrid lung abscess, both acute and chronic. Sulfadiazine was employed concurrently. The sodium salt of penicillin was administered intramuscularly in doses of 40,000 units every three hours. The sulfadiazine was given in the usual manner, sufficient to establish and maintain adequate blood levels. The treatment was continued until all clinical and roentgenologic evidence of pulmonary involvement had disappeared.

Nineteen of 21 patients with acute abscess recovered and showed complete roentgenologic resolution of the lesion. One patient left the hospital against advice, with an interlobar exudate between the right middle and lower lobes. Another patient died of meningitis but autopsy revealed no evidence of putrid lung abscess. Roentgenographic clearance of the lesion was noted in eighteen to seventy-eight days, with an average for the group of forty-two days. The right lower lobe was the seat of the abscess in 9 cases, and the left lower in 1 case. The right upper lobe was affected in 7 cases, and the left upper in 3. One patient had abscess formation in both the right and left lower lobes.

There were two recurrences among the 21 patients whose acute putrid abscesses had cleared under treatment.

Although no recoveries were noted in cases of chronic putrid lung abscess, 8 to 10 such patients became less toxic by virtue of the partial or complete clearing of the coexisting pneumonitis.

The concept that patients with acute putrid lung abscess require early surgical intervention deserves drastic revision.

Thirteen roentgenograms; 1 table.

STEPHEN N. TAGER, M.D.
Urbana, Ill.

Primary Atypical Pneumonia: A Report on 14 Cases Observed at the Royal Adelaide Hospital. P. W. Verco. M. J. Australia **1:** 254–266, Feb. 26, 1949.

Atypical pneumonia is apparently as yet a comparatively uncommon disease in Australia, since only 14 cases regarded as suitable for study were seen in a fourteen-month period. Many cases were excluded because of factors which would tend to confuse the clinical picture.

The cases fell into two groups from the x-ray standpoint. In the first group the lesions were localized; in the second, disseminated and focal, some even miliary in type. Some cases in each group showed areas of atelectasis, and resolution was slow.

Clinical features were similar to those in other reported series: usually an insidious onset, malaise, cough, headache, fever, sometimes mild chills, anorexia, vomiting and constipation, and pain in the chest. On physical examination the outstanding findings were râles and rhonci, cyanosis in severe cases, sometimes a pleural rub. Convalescence was prolonged.

Skin and serological tests were done in great detail to rule out diseases of known etiology.

Two cases terminated fatally. These are reported in detail, along with one which showed a leukemoid blood picture.

No films are reproduced, but the article can be highly recommended for its otherwise complete coverage of the subject.

Two photomicrographs; 2 tables.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

An Unusual Case of Clonorchiasis with Marked Eosinophilia and Pulmonary Infiltrations. George E. Cartwright. Am. J. Med. **6:** 259–266, February 1949.

A case of clonorchiasis with eosinophilia in the peripheral blood and bone marrow and roentgen evidence of bilateral pulmonary infiltrations is presented. The similarity and possible relation of this condition, Loeffler's syndrome, and tropical eosinophilia are discussed. It is predicted that clonorchiasis will be a problem in many of the returning military personnel from China, Japan, and Korea, and that this condition will have to be considered in patients presenting marked eosinophilia.

Four roentgenograms; 1 chart.

Angiocardiography in the Differential Diagnosis of Pulmonary Neoplasms. Harold Neuhof, Marcy L. Sussman, and Robert A. Nabatoff. Surgery **25:** 178–183, February 1949.

Robb and Steinberg have presented fundamental observations concerning the role of angiocardiography in a variety of intrathoracic lesions and noted changes in the branches of the pulmonary artery in tuberculosis and bronchiectasis, obstruction of the innominate vein by substernal goiter, and displacement of the great venous channels by mediastinal tumors or widespread fibrosing pulmonary lesions. The authors have used the same procedure, with the addition of a multiple exposure roentgen technic, to determine the effect of various neoplasms of the lung upon the pattern of the pulmonary artery and its branches.

Angiographic studies in cases of malignant tumors of main bronchi, which are usually infiltrative in nature, showed that the large pulmonary vessels in the area of the neoplasm are, in the majority of cases, partially or completely occluded. In one instance the customary roentgenogram revealed no tumor, but angiography demonstrated upward displacement of the main stem artery of the right upper lobe with spreading of the branch arteries. The presence of an infiltrating neoplasm was confirmed at operation.

In malignant tumors of the small or branch bronchi, similar findings were obtained. The vessels in the area of the tumor are irregularly distorted or occluded, but since the lesions are situated toward the periphery, only relatively small vessels are involved. Thus, even though the effects seen in the angiocardiograms are not as dramatic as with occlusion of a major pulmonary vessel, they are of substantial aid in establishing a diagnosis. These changes are to be contrasted with the effects produced by benign, slowly expanding lesions. In these cases, the vessels are displaced and surround the tumor but are intact. A small, well circumscribed malignant lesion may, however, present a vascular pattern identical with that of a benign intrapulmonary lesion. A case is cited, also, in which the clinical history and roentgen findings were those of malignant pulmonary neoplasm but angiocardiography failed to show any of the anticipated abnormalities of vascular pattern. Operation revealed a chronic pulmonary abscess with no evidence of neoplasm.

In mediastinal or other extrapulmonary tumors of even substantial size, angiocardiography usually reveals an essentially normal vascular arrangement, with only occasional displacement of an adjacent segment of lung with its vascular components. One case of thyroid carcinoma with multiple metastatic pulmonary nodules showed no detectable departure from the normal vascular pattern, presumably because there was no alteration in the arrangement of finer vascular branches.

Ten roentgenograms.

JOHN E. WHITELEATHER, M.D.
Memphis, Tenn.

Cystic Disease of the Lung. O. C. Brantigan. Dis. of Chest **15:** 192–205, February 1949.

Cystic disease of the lung is not an uncommon lesion; it may be either congenital or acquired. The cysts may be asymptomatic; they may produce symptoms due to increased pressure or infection within the cyst or may give rise to hemoptysis. Diagnosis can be made by roentgen examination, bronchography, bronchoscopy, and biopsy. A fluid-filled cyst may be confused with a neoplasm, and partially filled cysts must be differentiated from pyogenic abscesses and tuberculous cavities.

Since 1940 the author has treated 15 patients with cystic disease of the lung. Illustrations of his cases are included and demonstrate cystic disease diagnosed as chronic lung abscess; first diagnosed as acute empyema and later as chronic empyema; complicated by empyema; resulting from empyema; associated with bronchiectasis; asymptomatic and uncomplicated, with both air- and fluid-filled cysts.

Thirty-one roentgenograms.

HENRY K. TAYLOR, M.D.
New York, N. Y.

Bronchiogenic Cyst of the Mediastinum. J. Exalto and K. Waldeck. J. Thoracic Surg. **18:** 132–136, February 1949.

This article consists almost entirely of a report of a bronchogenic cyst treated in Holland in 1943. The patient was a 6-year-old girl with a history of repeated attacks of pneumonia and bronchitis. She was acutely ill, with cyanosis, dyspnea, cough, expectoration, and fever. Chest roentgenograms showed pneumonia at the right base and a smooth oval mass the size of a goose egg in the right superior mediastinum, compressing the trachea and right main bronchus. The cyst was lined with columnar ciliated epithelium and contained a thick gelatinous viscous fluid. Attached to it was a small hard lump containing cartilage. Mucous glands were present in the lump and in the wall of the cyst. The child made a good recovery and had no further attacks of pneumonia.

Two roentgenograms; 2 photomicrographs.

HAROLD O. PETERSON, M.D.
University of Minnesota

Intrathoracic Meningocele. Harvey J. Mendelsohn and Earle B. Kay. J. Thoracic Surg. **18:** 124–128, February 1949.

A case is reported of a 40-year-old female with no symptoms or physical findings referable to the chest, in whom a lesion was picked up on a routine photofluorogram. A smooth oval mass, 3 × 8 cm., was present adjacent to the right border of the 6th, 7th, and 8th thoracic vertebrae. The posterior margins of the 6th, 7th, 8th, and 9th vertebral bodies showed rather marked concave erosions, with widening of all the intervening intervertebral foramina. The patient also had generalized neurofibromatosis. In the belief that the chest tumor was a large dumb-bell type of neurofibroma, exploration was done and a big cystic cavity encountered which communicated with the subarachnoid space through the large 7th intervertebral foramen. The cord appeared normal.

From this surgical description it is difficult to understand the mechanism of erosion of the vertebral bodies, particularly the 9th, which was actually below the mass. No myelography was done, but is suggested as a good diagnostic preoperative procedure. The patient recovered satisfactorily but it was felt that the operation was unnecessary.

Four cases have been reported in the literature and in 3 of these there was associated neurofibromatosis.

Four roentgenograms; 1 photograph.

HAROLD O. PETERSON, M.D.
University of Minnesota

Atelectasis of the Right Upper Lobe. J. Tanca Marengo and Julio Mata Martinez. Dis. of Chest **15:** 226–232, February 1949.

The authors present the case history of a 52-year-old male with pulmonary dysfunction which was attributed to tuberculosis of the right upper lobe because of the x-ray findings. A second x-ray examination made five months later resulted in the inclusion of carcinoma and atypical pneumonia as diagnostic possibilities. A bronchographic examination revealed an occluded right upper lobe bronchus. A second bronchographic study, ten days later, showed the block to be incomplete. A third bronchogram, four months after this, showed contrast substance in the three branches and subdivisions of the right upper lobe bronchus. At this time pulmonary symptoms had completely disappeared.

The clinical picture originally suggested a subacute or chronic lesion, and, with the atelectasis, a bronchogenic carcinoma or tuberculosis was suspected. Subsequently, an acute clinical picture supervened, which eliminated the earlier diagnoses. The final diagnosis was atelectasis due to bronchial obstruction of inflammatory origin which subsequently resolved.

Nine roentgenograms. HENRY K. TAYLOR, M.D.
New York, N. Y.

Mediastinal Defect with Interpleural Communication Observed During Pneumothorax Therapy. Report of a Case. Isaac Epstein. Dis. of Chest **15:** 186–191, February 1949.

Mediastinal defect with interpleural communication is a rare anomaly, only 10 cases having been reported in the literature. The author gives the case history of a white male, aged 31, who received collapse therapy for a tuberculous lesion in the right upper lobe. Bilateral pneumothorax was apparent on subsequent x-ray examination, indicating a to-and-fro passage of air through the mediastinum. Three roentgenograms show the appearance before pneumothorax, bilateral partial collapse before a refill, and increased bilateral collapse after a refill. The thoracentesis was performed on the right side only. HENRY K. TAYLOR, M.D.
New York, N. Y.

Lutembacher's Syndrome Associated with Subacute Bacterial Endocarditis. Report of a Case. Edward R. H. Kurz and Isidore Fischer. New England J. Med. **240:** 178–179, Feb. 3, 1949.

This is a complete case report of a 47-year-old male with dyspnea, orthopnea, and hemoptysis of two months duration. The patient had had rheumatic fever twenty years previously. Examination of the heart showed a systolic thrill and a diastolic murmur at the mitral area. There was a diastolic murmur in the second and third left interspace and a loud systolic murmur at the apex. Fluoroscopy showed moderate enlargement of the outflow and inflow tracts of the left ventricle; horizontal and vertical enlargement of the left auricle; marked enlargement of the outflow tract of the right ventricle with some enlargement of the inflow tract; marked enlargement of the region of the pulmonary conus; and enlargement of the appendicular portion of the right auricle. An electrocardiogram showed right-axis deviation. Blood culture was sterile. The hemoglobin and red cell count fell to about half the normal level and shortly before death, on the twenty-fifth hospital day, anuria and temperature elevation of 101° F. had developed.

Autopsy showed cardiac enlargement, with narrowing of the mitral valve, which contained soft friable vegetations. The pathologist's report was interauricular septal defect, subacute bacterial endocarditis, healed rheumatic endocarditis, cardiac hypertrophy and dilatation, multiple pulmonary infarcts, and focal embolic nephritis.

This appears to be the fourth case reported in the literature of interauricular septal defect and mitral stenosis (Lutembacher's syndrome) complicated by subacute bacterial endocarditis.

Three illustrations, including 1 roentgenogram.
JOHN B. MCANENY, M.D.
Johnstown, Penna.

Constricting Vascular Rings. Report of Two Cases with Recurrent Respiratory Infections. Merl J. Carson and James Goodfriend. J. Pediat. **34:** 155–165, February 1949.

The diagnosis of double aortic arch is suggested primarily by (1) a stridor in infancy, (2) dysphagia, (3) vomiting after the introduction of solid foods into the diet, (4) recurrent respiratory infections.

With the increased rigidity of the trachea which comes with age, compression and angulation of this structure assumes less significance. However, relief by surgical intervention limits the possibility of the development of bronchiectasis and increases the well-being of the child, who would otherwise be subject to severe recurrent respiratory infections. Both tracheal constriction and angulation can be eliminated if the minor branch of the vascular ring is located dorsal to the esophagus; more commonly it is ventral, but relief may still be expected.

Two cases are presented and illustrated by esophagrams and tracheograms.

Fourteen roentgenograms.
HARRY J. PERLBERG, JR., M.D.
Baltimore (Md.) City Hospitals

Importance of the Prone Position in the Roentgenologic Diagnosis of Slight Mitral Disease. Sven Roland Kjellberg. Acta radiol. **31:** 178–181, Feb. 28, 1949.

The author cites the danger of minimizing the importance of a systolic murmur in the absence of other signs of organic heart disease. Often the conventional upright film of the chest and heart lends no aid in diagnosis, since it fails to demonstrate slight enlargement of various cardiac chambers because of diminished cardiac return in this position. The author advocates the prone position, with 30° caudal tilt of the tube, for roentgen examination of the heart in patients suspected of having minimal mitral involvement. The phase of cardiac cycle is also important. The left atrium is largest at the termination of ventricular systole. A case history is cited with supporting roentgenograms.

Six roentgenograms. R. A. HAYS, M.D.
Cleveland Clinic Foundation

Condition of the Cardiac Volume during Pregnancy. Sven Roland Kjellberg, Ulf Rudhe, and Torgny Sjöstrand. Acta radiol. **31:** 123–126, Feb. 28, 1949.

Since most investigators believe that there is no change in the cardiac volume during pregnancy, the authors decided to apply their method for determining cardiac volume to 81 pregnant women. An increase of between 30 and 35 per cent was found, beginning in

the second or third month, due probably to an increase in blood volume.

R. A. HAYS, M.D.
Cleveland Clinic Foundation

Relation of the Cardiac Volume to the Weight and Surface Area of the Body, the Blood Volume and the Physical Capacity for Work. Sven Roland Kjellberg, Ulf Rudhe, and Torgny Sjöstrand. Acta radiol. **31:** 113–122, Feb. 28, 1949.

The authors do not believe that there exists a close correlation between cardiac volume and the surface area of the body. They feel that cardiac volume is more closely related to the capacity for work than to the fixed measurements of surface area or weight.

They determine the cardiac volume in accordance with Larsson and Kjellberg's method (Acta radiol. **29:** 159, 1948. Abst. in Radiology **52:** 139, 1949), with the patient prone and a 30° caudal tilt of tube. The total hemoglobin content of the body is determined by using small quantities of carbon monoxide and then estimating the concentration of alveolar carbon monoxide.

In tests on normal men, women, and children, a high correlation was found between cardiac volume and the total and corrected hemoglobin values. The cardiac volume in the recumbent position thus appears to be a function of the blood volume. Cardiac volume stands in intimate relationship to the physical working capacity, which in turn is dependent on the total hemoglobin content of the body.

By correlating the cardiac volume to the blood volume or the total hemoglobin, one has far more opportunity of separating the pathological varieties of cardiac volume from the physiological than when the calculations are made per square millimeter of surface area.

Nine illustrations, including 1 roentgenogram; 1 table.

R. A. HAYS, M.D.
Cleveland Clinic Foundation

Diaphragmatic Hernia. A Review of the Literature and Report of Two Unusual Cases. Edwin H. Ellison. Am. J. Surg. **77:**152–161, February 1949.

The authors stresses the diagnostic difficulties in diaphragmatic hernia. The most important single factor in its recognition is its inclusion as a possibility to be considered in the differential diagnosis of diseases of the chest and upper abdomen. The symptoms are referable to the organs herniated and those displaced. The physical signs vary widely. The condition is progressive. Roentgen studies are the only reliable means of making a diagnosis, and these may have to be repeated, as the appearance may closely resemble that of a pulmonary process. Once a hernia is diagnosed, concomitant disturbance as the primary cause of the symptoms must be ruled out.

The author discusses the need for surgery and the operative approach. He presents two unusual cases illustrated by 10 roentgenograms.

ROBERT J. AYELLA, M.D.
University of Pennsylvania

THE BLOOD VESSELS

Unilateral Paralysis of Eye Muscles Associated with Intracranial Saccular Aneurysms. Edwin Boldrey and Earl R. Miller. California Med. **70:** 96–98, February 1949.

Unilateral paralysis or weakness of the eye muscles should suggest the possibility of an intracranial saccular aneurysm of the internal carotid or of one of its major branches. A bruit need not be present. Associated exophthalmos, especially of the pulsating type, is indicative of an arteriovenous aneurysm between the internal carotid and the cavernous sinus. In such instances, a bruit is usually heard.

Nine cases of saccular aneurysm of the internal carotid confirmed by angiography are reported. In 3, the initial symptom was oculomotor paralysis. In the other 6, involvement of adjacent cranial nerves, especially the trigeminal, or subarachnoid hemorrhage was responsible for the presenting symptoms.

Of the 9 patients, 2 were male and 7 female; the ages ranged from 3 to 53 years. All aneurysms were treated by ligation of the carotid artery in the neck and in 2 cases clips were used intracranially at the base of the aneurysm. Hemiparesis occurred fifty-four hours following surgery in one case.

MAURICE D. SACHS, M.D.
Cleveland, Ohio

Vertebral Angiography. Oscar Sugar, Lawrence B. Holden, and Chester B. Powell. Am. J. Roentgenol. **61:** 166–182, February 1949.

While attempting percutaneous carotid angiography, the authors occasionally injected the vertebral artery by accident, thereby obtaining useful information. In one case, for example, a metastatic carcinoma of the thalamus was revealed, and in another, of traumatic carotid-cavernous sinus fistula, the extent of the collateral circulation was demonstrated. The procedure has now been adopted as a deliberate measure for study of the vessels of the posterior fossa and has been carried out in over 20 successive cases with but two failures to obtain filling of the vertebral artery and one serious complication (post-angiographic hemiparesis below the level of the pyramidal decussation).

The technic is described in detail, and 5 cases are reported, the 2 mentioned above, 2 of basilar aneurysm pictured for the first time preoperatively, and 1 of posterior fossa arteriosclerosis.

An excellent review of the historical development of vertebral angiography as well as literary documentation of the incidence of vascular lesions of the posterior intracranial circulation is presented. As with cerebral angiography in general, the authors rightly state: "One gathers the impression that the value of this type of (vertebral) angiography rises with the ease of performance and the wide application in more cases."

Fifteen roentgenograms; 1 photograph.

J. A. CAMPBELL, M.D.
Indiana University

Retrograde Arteriography in the Diagnosis of Cardiovascular Lesions. I. Visualization of Aneurysms and Peripheral Arteries. Norman E. Freeman and Earl R. Miller. Ann. Int. Med. **30:** 330–342, February 1949.

Recent advances in vascular surgery have created a demand for more accurate methods of diagnosis. The present paper describes the authors' use of retrograde arteriography in the visualization of lesions of the aorta and of peripheral vessels. The procedure was employed in 11 cases.

The catheter technic described by Fariñas (Am. J. Roentgenol. **46:** 641, 1941. Abst. in Radiology **39:** 121, 1942) was used in the first case, but because of complications incident to this procedure, it was decided

to employ Fariñas' later method (Radiology **47:** 344, 1946). According to this technic, diodrast is injected at 15 pounds pressure through a trocar 1.5 mm. in diameter, the injection being accomplished in two seconds.

Retrograde arteriography of the abdominal aorta by injection of the contrast medium into the femoral artery proved unsuccessful in 4 patients. In 2 of these a large abdominal aneurysm was present, but in spite of the use of a 15 and a 16 gauge needle, with injection of 30 to 40 c.c. of 35 or 70 per cent diodrast, adequate visualization of the abdominal aorta was not obtained. Similarly in 2 patients with a clinical diagnosis of thrombosed abdominal aorta, visualization was not obtained.

Vascular lesions of the upper extremity were more successfully shown. The right subclavian artery was visualized by retrograde injection of the right common carotid artery in 1 case illustrated. In another case, retrograde arteriography was useful in showing the absence of a significant arterial component in a large angioma, and in still another in demonstrating an arteriovenous fistula located high in the left axilla.

Visualization of aneurysms of the thoracic aorta and innominate artery was attempted on three occasions. The results were not entirely satisfactory, presumably due to difficulty of introducing a sufficient quantity of radiopaque material rapidly.

The authors conclude that, although arteriography can best be accomplished by the injection of radiopaque material into the artery proximal to the lesion to be studied, occasionally the location of the lesion or its character makes it difficult to carry out this technic. Under such circumstances, retrograde arteriography may offer a method for adequate visualization. The danger of thrombosis at the site of injection, especially where a large needle is inserted into a small artery, is very real. This occurred in 3 patients. With the use of diodrast, the possibility of serious systemic reaction should also be considered, especially when the contrast medium enters the cerebral circulation.

Ten roentgenograms; 1 table.

STEPHEN N. TAGER, M.D.
Urbana, Ill.

An Arteriographic Demonstration of Collaterals Between Internal and External Carotid Arteries. F. Marx. Acta radiol. **31:** 155–160, Feb. 28, 1949.

The author reviews two of his previously published cases of internal carotid artery thrombosis and discusses collateral circulation between the external and internal carotid arteries and anastomatic connections between the ophthalmic artery and external carotid.

Existence of a collateral circulation between the external and internal carotids by way of the ophthalmic artery may be responsible for failures of surgical therapy in cases of arteriovenous aneurysms in the cavernous sinus and in cases where ligation of the internal carotid artery is carried out because of an arterial aneurysm.

Two cases are presented. In the first, a case of thrombosis of the internal carotid, the arteriogram shows filling of the cerebral vessels through collaterals from the ophthalmic artery by way of the middle meningeal. In the second, a case of bilateral thrombotic occlusion of the internal carotid, bilateral filling of cerebral vessels by reflux of blood from the enlarged ophthalmic arteries is shown in the arteriogram.

Filling of cerebral vessels by arteriography does not necessarily exclude an occlusion of the internal carotid. Widening of the ophthalmic artery might draw one's attention to the possible existence of a collateral circulation by way of this vessel.

In both of the cases reported here the middle cerebral artery was filled, while the anterior cerebral could not be visualized. The author points out that lack of filling of the anterior cerebral is in itself of minor importance. The anterior cerebral in these cases was probably supplied by way of the anterior communicating artery from the opposite side rather than by the ophthalmic.

The author indicates that ligation of the external carotid in order to elicit Schneider's middle-meningeal reflex may not be advisable in all cases of impeded cerebral circulation. A considerable cerebral blood supply may be effected by way of the external carotid. The question arises whether improvement of the cerebral circulation by way of the middle meningeal reflex compensates for the diminished blood flow to the ophthalmic artery. The volume of this blood flow can be estimated by arteriographic examination.

Three roentgenograms. R. E. WISE, M.D.
Cleveland Clinic Foundation

Measurement of the Rate of Venous Blood-Flow in the Legs of Women at Term and in the Puerperium, Using Radioactive Sodium. H. Payling Wright, S. B. Osborn, and Denise G. Edmonds. J. Obst. & Gynaec. Brit. Emp. **56:** 36–40, February 1949.

To measure the rate of venous blood flow in the legs of women at term and in the puerperium the authors made use of a technic previously used in normal subjects (Lancet **2:** 767, 1948). The limb was immersed in a water-bath at 40° for ten minutes to insure vasodilatation. One milliliter of sterile saline containing 5–10 microcuries of radioactive sodium was injected as rapidly as possible into one of the veins on the dorsum of the foot with the patient recumbent, and the arrival of the radioactive material in the vein at the groin was recorded electrically on a kymograph, the sensitive element of the apparatus being a gamma-ray Geiger-Müller counter suitably placed and screened.

Examinations were made on 50 women during the first stage of labor and between the fourth and tenth day of the puerperium. There was found to be a great retardation of the flow during labor, as compared to that in non-pregnant women, with a rapid return to normal in the puerperium.

Two charts. S. F. THOMAS, M.D.
Palo Alto, Calif.

A Method of Estimating the Time at Which a Counting Rate Changes, Using a Geiger-Müller Counter. S. B. Osborn and H. Payling Wright. Brit. J. Radiol. **22:** 110–116, February 1949.

The object of this study was to find the time required by venous blood to travel from a certain vein in the foot to the femoral triangle. The blood in a given vein at a given time was "marked" by an injection of a radioactive material which could subsequently be detected as it passed over a Geiger-Müller counter directed over the femoral vein in the groin. Na^{24} is the most useful isotope for this purpose. Certain difficulties were found in evaluating the point at which the rise in count occurs. The set-up used by the authors is described in detail. Essentially it is a com-

bination of rapid injection of a minimal amount of the isotope and recording the counts on a kymograph drum with the aid of a special amplifying circuit.

In 121 normal subjects the average foot-groin time was seventeen seconds, with a wide range of four to fifty seconds and a median of thirteen seconds. The error varies with the time, being one second in six and three in fifty.

Two photographs; 8 charts.

SYDNEY J. HAWLEY, M.D.
Seattle, Wash.

THE DIGESTIVE SYSTEM

Leiomyoma of the Esophagus: Report of a Case. Alfred Hurwitz. Surgery **25:** 304–306, February 1949.

Benign tumors of the esophagus are rare. Since symptoms are usually absent, the diagnosis is usually made roentgenographically.

The author presents a case in a man of 31, in whom the tumor was picked up on a routine chest film. The appearance was considered to be suggestive of a bronchogenic cyst, and operation was performed. Actually a correct preoperative diagnosis should have been made because of the sharp angulation of the esophagus, described by Schatzki and Hawes (Am. J. Roentgenol. **48:** 1, 1942) as characteristic of extramucosal intramural esophageal tumors, the normal mucosal pattern, and the absence of symptoms. The fact that both lateral walls were compressed by the tumor should have added support to such a diagnosis.

These tumors should be approached extramucosally without entering the lumen of the esophagus.

Two roentgenograms; 1 photograph.

JOHN E. WHITELEATHER, M.D.
Memphis, Tenn.

Vascularisation of the Human Stomach. A Preliminary Note on the Shunting Effect of Trauma. A. E. Barclay and F. H. Bentley. Brit. J. Radiol. **22:** 62–67, February 1949. Also in Gastroenterology **12:** 177–183, February 1949.

For the purpose of this study radiopaque substances were injected into the arteries of stomachs excised at operation for duodenal ulcer and into stomachs removed from the cadaver.

In the normal stomach the vascular system may be divided into three zones: the larger arteries running through the muscular coat into a second zone in the submucosa, forming a rich plexus communicating finally with the capillaries in the mucosa. The distribution of the circulation and its changes are demonstrated by Barclay's method of microradiography.

In 12 stomachs removed at operation the smaller anastomotic circulation could be demonstrated in only a few scattered areas, whereas in stomachs removed from cadavers the circulation in these areas was always free. This suggested that an arteriovenous shunt mechanism existed in the stomach similar to that described by Trueta *et al.* (Studies of the Renal Circulation, Oxford, 1947) in the kidney. The conditions of surgical trauma would favor the operation of such a shunt mechanism if it were present.

To check on this observation, stomachs exposed at operation were carefully observed. Immediately on opening the peritoneum, the veins were dark, but after a few minutes became definitely pinkish. Blood samples taken immediately on opening the peritoneum showed an oxygen saturation of 74 per cent. Second samples, taken three minutes later, showed an oxygen saturation of 94 per cent. Such a rapid change strongly suggested the direct passage of blood from the arterial side to the venous, through an arteriovenous shunt.

If such a shunt is present and is analogous to that in the kidney, it should be possible to prevent it by blocking the sympathetics. To test this hypothesis, one patient for gastrectomy received a combination of inhalation and spinal anesthesia up to T 1-2. The blood pressure fell from 145/85 to 80/40 and 40/? during the operation. The vessels of the excised stomach were injected in the usual way, and microradiographs were obtained. These showed a remarkable difference from all other operative specimens, all the mucosal vessels being abundantly filled.

Although this is a preliminary report, it offers strong evidence that there is an arteriovenous shunt mechanism in the stomach similar to that in the kidney and that it is controlled by the autonomic nervous system.

Six roentgenograms (3 microarteriograms); 1 drawing.

SYDNEY J. HAWLEY, M.D.
Seattle, Wash.

Effects of Tetraethylammonium Chloride on the Human Gastrointestinal Tract. Rosalie B. Neligh, John F. Holt, Richard H. Lyons, Sibley W. Hoobler, and Gordon K. Moe. Gastroenterology **12:** 275–289, February 1949.

The authors studied the effects of tetraethylammonium on gastric secretion in 8 patients with no apparent abnormality of the digestive tract and in 6 with a previous history of peptic ulcer. Repeated aspirations of the stomach contents were made at fifteen-minute intervals before and after administration of the drug. Changes in gastro-intestinal motility were studied in 38 patients. In each case control examinations were made with barium meals a few days before the administration of tetraethylammonium.

It was found that tetraethylammonium chloride in sufficient dosage given either intravenously or intramuscularly produces a sudden but temporary cessation of motility in the stomach and small bowel, this period of atony depending on the dosage of the drug. Little or no effect occurs in the colon or esophagus. The secretion studies showed that the drug will also inhibit gastric secretion to a very marked degree. This effect is likewise temporary. The pain of peptic ulcer was temporarily relieved.

A completely satisfactory explanation of the gastro-intestinal effect of tetraethylammonium in the human subject is not yet available. The authors postulate that the human gastro-intestinal tract, suddenly separated functionally from both sympathetic and parasympathetic control by the action of the drug, cannot assume spontaneous activity for a variable period.

Six roentgenograms; 3 graphs.

EDWARD E. LEVINE, M.D.
Dearborn, Mich.

Prolapse of Redundant Gastric Mucosa. Arthur M. Cove and Wilfred C. Curphey. Surg., Gynec. & Obst. **88:** 108–114, January 1949.

In a review of 650 consecutive gastro-intestinal examinations, the authors found 22 cases of prolapsing gastric mucosa, or 3.38 per cent. The etiological factors which have been suggested for this condition by various

observers are: (1) the presence of a small unrecognized mucosal ulcer resulting in a localized hyperplasia of the gastric mucosa, (2) hypertrophic gastritis, (3) persistent hypermotility of the stomach, (4) congenital variation in the anatomical structure of the stomach resulting in an abnormally hypermobile mucosa on the surface of the gastric muscularis; any or all of these are probably preceded by a disturbance in gastric peristalsis and function.

The symptomatology is varied, with no characteristic picture, and may be influenced by the extent and the condition of the prolapsed mucosa. Generally the diagnosis can be made only by exclusion of other gastro-intestinal tract disorders and the presence of the characteristic roentgen signs described by Eliason, Pendergrass, and Wright (Am. J. Roentgenol. **15:** 295, 1926). The major symptoms include intermittent epigastric distress, with cramping pains and a varying food relationship, a sense of fullness, bloating, heartburn, nausea, vomiting, and occasionally gastro-intestinal hemorrhages and secondary anemia which may be mistaken for pernicious anemia. The physical findings are usually inconclusive except for the occasional pathognomonic finding of a small epigastric mass in the region of the pylorus, having a soft doughy feel and imparting a characteristic sensation to the examining fingers on reduction, similar to that experienced during the reduction of a hernia and probably representing the sliding of the prolapsed mucosa back through the pyloric ring.

Roentgenographically the prolapse of redundant gastric mucosa into the duodenal bulb is represented by a circular or irregularly circular filling defect in the base of the duodenal bulb, frequently lobulated and having a mushroom- or cauliflower-like appearance, with folds continuous with the gastric rugae. The defect is best seen in the prone position in the right horizontal oblique projection. There is no disturbance in peristaltic activity and no irritability in the cap is present.

An attempt should be made to classify the prolapse as mild, moderate, or severe. Conditions to be differentiated include: (1) prolapsing polypoid tumor of the pyloric end of the stomach, (2) hypertrophy of the pyloric sphincter, (3) duodenitis, (4) duodenal ulcer, (5) hypertrophic gastritis, (6) polyp of the duodenum.

Conservative treatment, with rest in bed, freedom from tension, elimination of condiments, tobacco, alcohol, and caffeine, plus an ulcer regime, is recommended in the majority of cases. Cases which are intractable to medical management and those having pyloric obstruction with persistent recurrent vomiting or repeated gastro-intestinal hemorrhages should be treated surgically, preferably by antrotomy, with division of the pyloric musculature and resection of an abundant amount of the prolapsing mucosa.

Five operated cases are reviewed.

Four roentgenograms.

ROY GREENING, M.D.
University of Pennsylvania

Detection of Gastric Carcinoma by Photofluorographic Methods. Part I. Introduction. Part II. Equipment Design. John F. Roach, Robert D. Sloan, and Russell H. Morgan. Am. J. Roentgenol. **61:** 183–194, February 1949.

In their introductory paper, the authors discuss the high mortality in cancer of the stomach and the importance of early diagnosis and treatment. To accomplish the latter, methods must be developed whereby large segments of the population may be examined at regular intervals to find the asymptomatic cases. The photofluorographic process is considered the most feasible procedure for this purpose. To determine its efficiency, a pilot study has been instituted, using the male out-patient population of the Johns Hopkins Hospital above the age of forty. The study will cover a period of five years and the observations will be the subject of future reports.

In the second paper the equipment and technic for such a study are described. By the use of modern optics and faster fluoroscopic screens, photofluoroscopy can be performed efficiently, with no more radiation to the patient than is received in conventional roentgenography.

The nucleus of the installation for the proposed study is the 70-mm. Schmidt camera with a f/ number rating of 0.75 and with a speed approximately five times greater than the photofluorographic cameras in common use. A standard 200-ma. generator and a rotating anode tube are used. The grid-screen-camera assembly (Patterson type E-2 screen and special Liebel-Flarsheim cross-hatched stationary grid) is mounted beneath a horizontal roentgenographic table to permit examination of the patients in the recumbent position, thereby assuring a completeness of study not attainable in other positions. A photoelectric automatic timer of essentially conventional design is employed. Exposures are of the order of 0.5 second.

Six films are taken, 3 following the ingestion of a small amount of barium and 3 after a larger quantity is ingested. One graph, 2 diagrams, a photograph of the equipment, and 6 photofluorograms are reproduced.

J. G. LORMAN, M.D.
Indiana University

Primary Carcinoma of the Duodenal Bulb Mimicking Duodenal Ulcer. Jameson L. Chassin and J. William Hinton. Gastroenterology **12:** 312–322, February 1949.

Carcinoma of the duodenum may be more common than generally supposed. It may be that such neoplasms are not infrequently overlooked by leaving the ulcer *in situ* when doing partial gastrectomy for duodenal ulcer. The authors encountered three cases of carcinoma of the first portion of the duodenum in a period of thirty months. The three case reports are presented together with photomicrographs. In none of the cases did either the clinical or the roentgenographic findings suggest malignancy.

Six photomicrographs.

EDWARD E. LEVINE, M.D.
Dearborn, Mich.

Intussusception in Adults with Small Bowel Tumors. Robert M. Lowman and William Mendelsohn. Gastroenterology **12:** 290–301, February 1949.

Among adults, the most common cause of intussusception is a tumor of the bowel. In most instances the tumor is benign. The major symptoms are those of acute or chronic intestinal obstruction, and bleeding. The roentgen features are reviewed and two cases with typical findings are described.

The characteristic defect in intussusception has been variously described as a "pincers effect," a "beak defect," and a "cupola defect." It is produced by filling of the space between the receiving layer of bowel (the

intussuscipiens) and the invaginated portion (the intussusceptum). There may be a narrowing of the bowel lumen, either to the point of complete obstruction or to a narrow channel through which the barium passes in a thin stream. As the column is followed through the narrowed intussusceptum, it widens into a normal section of bowel and then enters the space between the two layers of the bowel, producing a spiral sheath or concentric ring appearance. The cause of the intussusception is rarely demonstrable roentgenographically.

The authors stress the importance of surveying the small bowel in cases of persistent melena, despite the slim chance of finding the cause of bleeding in the small bowel. [It is estimated that there are 266 potential sources of bleeding in the stomach and duodenum for each one found in the small intestine beyond the duodenal bulb.]

Five roentgenograms. EDWARD E. LEVINE, M.D.
Dearborn, Mich.

Involvement of the Ileum in Chronic Ulcerative Colitis. Fred J. McCready, J. Arnold Bargen, Malcolm B. Dockerty, and John M. Waugh. New England J. Med. **240:** 119–127, Jan. 27, 1949.

A complete pathologic study was made of 23 postmortem specimens of bowel in cases of diffuse chronic ulcerative colitis in which the ileum was involved and 6 surgical specimens that included the involved terminal ileum. Of 103 cases of chronic ulcerative colitis, 28 per cent showed also involvement of the terminal ileal segment.

In 22 cases, the terminal ileum showed the same gross pathological picture as found in the colon. In the other 7 cases, there were ulcers appearing intermittently in the ileum, with normal intervening mucosa. The ileal reaction was invariably less severe and less advanced than that in the colon. In the severer cases, the inflammatory change represented a direct continuation of the changes in the colon through the ileocecal valve, characterized by long lines of longitudinally running ulcerations. The ulcerations did not have any constant relation to the mesentery as seen in regional enteritis but were distributed over the whole lumen of the small bowel. The involved ileal wall was not thickened, nor was stenosis of the intestinal lumen observed. The extent of involvement measured from a few centimeters to several feet. Microscopically, the predominant features in the mucosal coat were ulceration and denudation. The ulceration varied in degree from a superficial erosion to a deep sloughing necrosis. Perforations in the bowel wall were present in some specimens.

Because of the critical condition of some of the patients, barium-enema studies were done in only 19 of the 29 cases. There was a roentgenologic report of ileal involvement in 4 cases, and in a review of the films 6 additional cases were found in which definite involvement of the terminal ileum was evident. The average length of the segment of ileum involved, as noted roentgenographically, was about 1 foot.

It is believed that ileal involvement occurs in both the acute fulminating disease and in long-standing chronic cases. It represents an added hazard when ileostomy must be performed, and is probably one of the factors that retards the healing process in the colon in chronic ulcerative colitis.

Seven illustrations, including 2 roentgenograms.
JOHN B. MCANENY, M.D.
Johnstown, Penna.

Volvulus of the Cecum, with a Review of One Hundred Cases in the Literature and a Report of Six New Cases. J. L. Donhauser and S. Atwell. Arch. Surg. **58:** 129–148, February 1949.

Of 100 cases of volvulus of the cecum reviewed, about half occurred between the ages of twenty and forty-five, and the distribution between the sexes was equal. The signs and symptoms are those of bowel obstruction with distention and often a mass. X-ray examination demonstrates the obstruction, but is seldom typical in other respects. Easton's sign, the presence of a cecum dilated with gas with an obstruction to barium enema distal to it, "organic lesions excluded," is mentioned. [It appears to the abstractor that the exclusion of organic lesion is something of a joker in this sign!]

Volvulus of the cecum should be considered in all cases of right-sided pain in association with a long history of constipation and previous similar attacks. Treatment is surgical, the exact procedure being adapted to the condition found at operation; but the earlier the operation, the better the end-result.

The authors report 6 cases.

Eight illustrations, including 6 roentgenograms; 3 tables. LEWIS G. JACOBS, M.D.
Oakland, Calif.

Volvulus of the Sigmoid. Lawrence Essenson and Leon Ginzburg. Am. J. Surg. **77:** 240–249, February 1949.

Eight cases of proved volvulus of the sigmoid colon are presented. The authors believe that in the majority of cases an accurate diagnosis can be made by roentgenographic examination of the abdomen in conjunction with the history and physical findings.

No intra-abdominal pathological conditions were found which might be predisposing factors to the occurrence of volvulus. An elongated mesocolon and a redundant pelvic colon were present in all cases. The clinical features were those associated with acute obstruction of the colon from any other cause.

From the standpoint of roentgenologic diagnosis, exposures made in the following manner are recommended: (1) an anteroposterior supine film, (2) a postero-anterior prone film, and (3) an erect film of the abdomen. Examination of the colon with contrast medium was not employed, and the plain films were made before the administration of enemata or irrigations.

The characteristic x-ray findings were a greatly distended loop of colon with two adjacent vertical arms, each containing a gas-fluid level, extending to the liver on the right or the diaphragm on the left. The proximal colon was usually dilated, but to a lesser degree.

The treatment for acute volvulus is immediate operation with untwisting of the obstructed loop and the insertion of a rectal decompression tube. If the blood supply has been compromised an exteriorization procedure is indicated.

Seven roentgenograms. DOUGLAS NAGLE, M.D.
University of Pennsylvania

Volvulus of the Sigmoid Colon. Report of a Case. Albert H. Staderman and Robert E. Booth. U. S. Nav. M. Bull. **49:** 75–85, January-February 1949.

This article represents a brief review of the diagnostic points of volvulus of the colon as exemplified by a single

case report. The authors feel that the most reliable single diagnostic maneuver is a barium-enema study. The roentgen picture in their patient was typical, showing the "ace of spades" appearance, as well as the "corkscrew" arrangement of the mucosa where the twist is clockwise.

It is of interest that the obstruction of the bowel of this patient was relieved by an enema at one time in the course of his history. He had a total of three attacks of obstruction, or partial obstruction, before he was finally operated upon.

Five roentgenograms; 1 photograph.

S. F. THOMAS, M.D.
Palo Alto, Calif.

Cholecystitis Emphysematosa. Edward E. Jemerin. Surgery **25:** 237–250, February 1949.

Inflammation of the gallbladder with grossly discernible gas formation is rare but possibly not as rare as the small number of recorded cases indicates. Since the first case was published in 1901 (Stolz: Virchows Arch. f. path. Anat. **165:** 90, 1901), 14 additional cases have been reported. A brief description of these is given and a new case is recorded in a patient with uncontrolled diabetes and a pericholecystic abscess containing gas under tension. *Clostridium oedematiens* in pure culture was obtained from the pus. Roentgenograms showed gas filling the lumen of the gallbladder, outlining its wall, and extending into the surrounding tissue. The patient died on the twenty-fourth day after operation, from a cerebral accident.

Cholecystitis emphysematosa is an acute inflammation of the gallbladder due to a gas-producing organism, with gross gas accumulation. The gas may be in the lumen of the gallbladder or the wall and frequently extends into the pericholecystic region; it is demonstrable radiographically. An anaerobe of the Clostridium group is almost always the causative organism.

Infection of the gallbladder is usually secondary. According to Whipple, it follows one of the following routes: (1) the portal stream to the liver, hence into the bile capillaries and the gallbladder or through the biliary lymphatics to the subserous coat of the gallbladder; (2) the hepatic artery; (3) retrograde lymphatic infection from the duodenum, colon, or appendix; (4) from contiguous inflamed organs; (5) ascending infection from the duodenum through the papilla of Vater.

Gas-forming organisms usually produce a gangrenous gallbladder with crepitation in the wall, from which a foamy liquid can be expressed. The lumen of the gallbladder also shows an accumulation of gas, which may entirely or partially replace the fluid content. Clinically the picture is that of a severe acute cholecystitis with pericholescystitis. Stones frequently can be visualized in the gas-filled bladder. Differentiation must be made from a fistulous communication with the gastro-intestinal tract, which is more common. In the latter condition, the biliary duct system is usually well shown in addition to the gallbladder and common duct. This is in contrast to the enlarged gallbladder shadow surrounded by a denser ring representing the gas within the wall and adjacent tissues that characterizes gaseous cholecystitis. Lipomatosis of the gallbladder also casts an x-ray shadow showing a circumferential ring, but there is no gas within the lumen of the organ.

The author believes that surgical treatment is indicated in the acute phase, although he admits that if the infection can be held in check by chemotherapy and there is no evidence of spread it may be wise to delay surgery for a short interval. Chemotherapy should be used in conjunction with surgery.

Three roentgenograms.

JOHN E. WHITELEATHER, M.D.
Memphis, Tenn.

Iodobil as a Gallbladder Contrast Medium. W. Weyland and C. Maier. Schweiz. med. Wchnschr. **79:** 93–95, Feb. 5, 1949. (In German)

The authors review their experiences with "Iodobil Cilag" in 100 patients. This is a proprietary preparation which is chemically 3-(4′-oxyphenyl)-2-phenyl propionic acid [a close chemical relative of iodoalphionic acid]. All of the patients were subjected to duodenal intubation for recovery of fractional specimens of bile, which were then studied by chemical, bacteriologic, and cytologic methods. Cholecystography followed, and if no shadow was obtained on the first trial, a second or even third attempt was made. Only 1 patient had a reaction, consisting of vomiting followed in an hour and a half by a generalized urticaria which cleared spontaneously.

Of 110 cholecystographic examinations, 67 led to excellent visualization, 17 to faint visualization, and 26 to no visualization. The failures were seen in 18 patients. Of these, 7 had repeated examinations, and in 2 these led to satisfactory visualization. In 20 of the 67 cases with excellent filling, unfavorable factors which might have been expected to interfere with filling were found; such factors were present in 14 of the 17 failures. Of the 84 patients in whom filling was observed, 58 proved to have normal gallbladders; 12 had stones, 13 had decided ptosis or enlargement, and 1 had an anomalous septum as shown by the films. The conclusion is that this drug is a suitable cholecystographic medium.

Eight roentgenograms; 3 tables.

LEWIS G. JACOBS, M.D.
Oakland, Calif.

SITUS INVERSUS

Situs Inversus with Associated Abnormalities: Review of the Literature and Report of Three Cases. J. Robert Johnson. Arch. Surg. **58:** 149–162, February 1949.

Situs inversus is more common than generally believed; over 1,000 cases have been recorded. The occurrence in the general population is estimated as over 1 per 1,379 persons. The number of organs involved and the degree of involvement vary greatly. Although the presence of other congenital anomalies and of acquired diseases is at least as great as in situs normalis, the condition is not incompatible with normal health.

Situs inversus may result from a true mutation, inherited as a recessive characteristic, or from external forces acting on the fetus. The condition can usually be diagnosed by physical examination, with electrocardiography and roentgenography occupying a confirmatory role. The cases of three patients in whom this condition was an incidental finding are reported; one female had an associated cervical rib and a spina bifida occulta of the first sacral segment.

Five roentgenograms; 1 electrocardiogram.

LEWIS G. JACOBS, M.D.
Oakland, Calif.

THE MUSCULOSKELETAL SYSTEM

Diaphysial Aclasis. H. A. Thomas Fairbank. J. Bone & Joint Surg. **31-B:** 105–113, February 1949.

Diaphysial aclasis, known also as multiple exostoses and hereditary deforming chondrodysplasia, is characterized by the presence of cancellous exostoses capped with cartilage and by failure on the part of the periosteum to model the metaphyses of long bones in a normal manner. Diaphysial aclasis and dyschondroplasia are often regarded as variations of the same developmental error and are frequently confused. According to the author, both result from a fault of the epiphyseal plate with misplaced nests of cartilage. Exostoses are outgrowths of cancellous bone on the surface of the parent bone: dyschondroplasia, on the other hand, is characterized by columns or masses of cartilage lying inside the metaphyses.

Hereditary and familial influences play a definite part in the incidence. Two-thirds of the reported cases are in males and the etiology is unknown. The size and number of exostoses vary considerably. The bones chiefly affected are the long bones formed in cartilage. The exostoses project from the surface of the metaphyses or adjacent parts of the shaft. Exostoses are rare in the middle of the shaft and are never seen in the epiphyses. In the spine, the neural arches are affected, and only seldom the vertebral bodies. A varying degree of dwarfism may be associated with exostoses.

Symptoms associated with exostoses depend on their size, shape, and position. The roentgenograms show a broad base fused with the parent bone. The appearance is quite characteristic; on the side near the center of the shaft the projection of bone rises abruptly, almost at right angles to the surface of the shaft, whereas on the other side it slopes toward the epiphysis. The apex of the exostosis is more often rounded or mushroom-shaped. When the exostoses are multiple, there may be irregular enlargement and abnormal shape of the metaphyses and adjacent parts of the shaft.

On section an exostosis is seen to consist of cancellous bone, directly continuous with the parent bone, the apex being covered with a cap of cartilage from which it grows. The cartilage cap is covered by a bursa.

The rate of growth of different exostoses varies considerably. Some may show little change over a period of years, while others may grow and by their size or shape produce symptoms. In the majority of cases when growth of the skeleton ceases the exostosis ceases to grow, and the cap becomes ossified. There is always the possibility of osteochondromatous changes and malignant degeneration.

Five case histories are appended, with 12 roentgenograms and 1 photograph.

JOHN R. HODGSON, M.D.
The Mayo Clinic

Dysplasia Epiphysialis Punctata. H. A. Thomas Fairbank. J. Bone & Joint Surg. **31-B:** 114–122, February 1949.

Dysplasia epiphysialis punctata (synonyms: stippled epiphyses; chondrodystrophia calcificans congenita) is a rare disease of infancy characterized by the presence of a number of discrete centers of unusual density in many of the epiphyses. There is no evidence of hereditary or familial influence. Females are affected more frequently than males in the proportion of two to one. Fourteen of the 16 cases found in the literature were seen before the age of nine months. The dysplasia undoubtedly begins in fetal life.

Dwarfing is usually present. The affected epiphyses are enlarged. Limitation of motion was present in several cases, with varying degrees of contracture. Some of the associated features that have been described are thickening of the skin, broad nose and large nostrils, bilateral congenital cataract, dulled intellect, and general weakness.

The roentgenographic appearance of the epiphysis is that of a diffuse stippling, as if there were many small discrete centers of varying size and number. These centers may become smaller and fewer in number or they may show a tendency toward fusion. Often they appear much earlier than the normal ossification center for the epiphysis. The epiphyses most frequently affected are the upper and lower femoral, upper tibial, and upper humeral. The radius, ulna, lower tibia, and bones of the hand are less frequently involved. Stippling has been seen in the proximal ends of the ribs but not in the iliac crests. The femoral and humeral shafts are short, thick, and splayed, with an irregular surface at the epiphysial line.

The author knows of no case with generalized changes in which the appearance of the epiphyses was followed over a period of years. In one case with involvement of a single bone there was definite improvement with fusion of the centers over a nine-year period. Half of the patients are known to have died.

The pathologic findings consist of patchy mucoid degeneration and cystic spaces in the cartilaginous epiphyses near the articular surfaces. In some places areas of degeneration were invaded by blood vessels and a core of fibrous tissue was formed. Other investigators report circumscribed polymorphous deposits of chalk in the cartilage, near which are larger confluent areas of calcification. In other areas new bone was replacing the chalky areas. There was also diminution of the zone of ossification between bone and cartilage at the epiphysial lines.

The discrete stippling is distinct from the mottling and epiphysial irregularity seen in dysplasia epiphysialis multiplex and sometimes in cretins.

Ten roentgenograms, and brief descriptive notes of 4 cases.

JOHN R. HODGSON, M.D.
The Mayo Clinic

Difficulty of Differential Diagnosis Between Primary and Secondary Tumors of Bone. Mauro Piemonte. Ann. radiol. diag. **21:** 10–28, 1949. (In Italian)

This is an excellent article illustrating how difficult it can be to differentiate primary from secondary malignant tumors of bone on the basis of radiographic findings alone. This question may be of great importance where a primary neoplasm cannot be found elsewhere. The article further seeks to disprove the contention of the greater reliability of radiologic diagnosis as compared with the microscopic findings.

Thirteen illustrations, including 8 roentgenograms.

CESARE GIANTURCO, M.D.
Urbana, Ill.

Carcinoma Developing in Chronic Draining Cutaneous Sinuses and Fistulas. A. K. McAnally and Malcolm B. Dockerty. Surg., Gynec. & Obst. **88:** 87–96, January 1949.

The authors have reviewed all of the cases, from the

Mayo Clinic, of malignant changes occurring in chronic cutaneous fistulas and sinuses. A total of 9 cases of carcinoma occurring in approximately 4,000 cases of osteomyelitic sinuses are reported, 2 of which showed metastases to regional lymph nodes. Nine cases recorded in the literature also showed proved metastases. In addition, the writers report 3 cases of carcinoma arising in approximately 3,000 cases of anal fistulae, and 1 case of carcinoma in approximately 1,500 cases of empyema drainage tracts.

Malignant changes in osteomyelitic sinuses should be suspected when a growth appears in the sinus, the discharge becomes hemorrhagic or more foul smelling, a painful swelling appears, and when x-ray examination reveals pathologic fracture or areas of rarefaction surrounding the osteomyelitic cavity. If biopsy reveals epithelial hyperplasia, the tract should be excised and further studied for malignant changes. If carcinoma is found, amputation is recommended in cases of osteomyelitis, and radical excision for fistula-in-ano and empyemic sinuses. Prophylactic regional lymph node dissection should be considered.

The following general points are emphasized: (1) the occurrence of carcinoma in chronic inflammatory sinuses is not particularly rare. (2) The diagnosis can be made clinically at a relatively early stage. (3) The neoplasms are, in general, slow growing and metastasize late.

One roentgenogram; 7 photomicrographs.

DOUGLAS B. NAGLE, M.D.
University of Pennsylvania

Congenital Malformation of Vertebrae (Hemivertebrae) with Aplasia of Corresponding Ribs, Associated with a Lateral Meningomyelocele. Report of a Case. I. Ralph Goldman. Arch. Path. **47:** 153–159, February 1949.

A case of a lateral meningomyelocele with absence of the right halves of the first through the ninth thoracic vertebrae and the associated ribs in a newborn infant is presented, including roentgenologic and necropsy observations. The embryonal development of the vertebral bodies and corresponding ribs and the theory of the genesis of defects such as those reported are discussed.

Five illustrations, including 1 roentgenogram.

Osteitis of the Spine. Charles D. Donahue. J. Urol. **61:** 405–409, February 1949.

The author believes that osteitis of the spine is a possible complication of prostatic surgery, though it is relatively rare. Many infected prostates are operated upon which could be a source of infection in some other part of the body. If metastatic cells from the prostate can be spread *via* the prostatic venous plexus to the vertebral column, it would seem that infected material could be spread in the same manner.

Two cases of osteitis of the spine are presented, both of which occurred as a complication of prostatic resection. The progress of bone repair in each instance was followed by frequent roentgenograms. There was finally fixation of the involved area of the spine by calcification and ossification, a finding contrary to that seen in metastases from carcinoma of the prostate.

Twelve roentgenograms.

RICHARD C. RIPPLE, M.D.
University of Pennsylvania

An Analysis of 200 Cases of Ankylosing Spondylitis. N. R. W. Simpson and C. J. Stevenson Brit. M. J. 1: 214–216, Feb. 5, 1949.

Two hundred cases of ankylosing spondylitis seen at the Royal National Hospital for Rheumatic Diseases, Bath (England), during the years 1938–48 were studied, and the statistical data are presented. Seventy-nine per cent of the patients were male and 21 per cent female; 40 per cent were between the ages of twenty and thirty years. There was a history of sepsis in 22 cases, and of trauma in 30 cases. A family history of the condition was obtained in 2 cases. In 62 patients the onset was acute; in the remainder it was considered as insidious. The initial symptoms were chiefly pain and stiffness.

The radiographic findings are classed in four groups: (1) bony ankylosis, (2) gross changes, but no ankylosis, (3) osteoporosis or other minimal changes, and (4) no abnormality. The sacroiliac joints were most often affected, with the lumbar spine next. Changes at other joint sites, generally speaking, varied with the severity of the disease.

The authors feel that this entity is completely separate from rheumatoid arthritis.

Three tables.

JOE B. SCRUGGS, JR., M.D.
University of Arkansas

Neurofibroma: Benign Intraspinal-Intrathoracic "Hour-Glass" Tumor with Paraplegia. Eben Alexander, Jr., and Robert M. Janes. Ann. Surg. **129:** 267–273, February 1949.

A case of benign neurofibroma of the "hour-glass" type involving the dorsal spine and the thoracic cavity and causing paraplegia is presented. A roentgenogram disclosed a large discrete rounded mass in the left upper chest posteriorly, and destruction of the head and neck of the left fourth rib. Films of the thoracic spine showed loss of the pedicle of the fourth dorsal vertebra on the left side and erosion of the adjacent pedicles. An initial diagnosis of bronchogenic carcinoma with invasion of the ribs and spine was made, and the patient was given intensive roentgen therapy without benefit. Surgical removal of the tumor resulted in a rapid relief of symptoms. The authors emphasize the danger of subjecting any tumor causing spinal cord compression to radiotherapy without prior biopsy.

Two roentgenograms; 1 photomicrograph.

DONALD S. CHILDS, JR.
The Mayo Foundation

Intervertebral Disc Injury. An Analysis of One Hundred and Thirteen Industrial Cases. Henry C. Marble and William A. Bishop. J. Indust. Hyg. & Toxicol. **31:** 46–49, January 1949.

A series of 113 industrial cases with 117 operations for rupture of an intervertebral disk has been analyzed from the standpoint of etiology, diagnosis, operative results, and costs, and a comparison of the data made with those in an earlier series of 92 patients (J. Indust. Hyg. & Toxicol. **27:** 103, 1945. Abst. in Radiology **46:** 302, 1946). In the second series, 75 cases followed strains, 31 followed falls and contusions, and 7 were the result of twisting injuries; the proportion of cases resulting from each type of trauma is approximately the same in the two series.

Roentgenograms of the spine were taken soon after

injury in 97 of the 113 cases. Fifty-five of the examinations were reported as negative; the findings reported in the remaining 42 cases were: narrow intervertebral space, 18; arthritis, 10; spondylolisthesis, 4; rupture of disk, 3; scoliosis, 2; lipping, 2; kyphosis, 1; increased density of disk, 1; loss of disk, 1. Later, 46 cases underwent x-ray studies in which contrast media were used—pantopaque, lipiodol, and air. In the cases reported as positive, the diagnosis with pantopaque and lipiodol was confirmed at operation in all cases, 21 and 13, respectively, while with air the diagnosis was confirmed in only 9 of 11 cases. Comparison with the first series seems to indicate that doctors are becoming more skilled in the technics and interpretation of myelograms.

Of the 92 cases in which the neurosurgeon made a positive preoperative diagnosis of ruptured disk, 7 were negative at operation; and of 10 considered negative, 7 were positive at operation. Of the 77 cases in which the orthopedic surgeon made a positive preoperative diagnosis of ruptured disk, 5 were negative at operation; of the 16 considered negative, 12 were positive at operation.

In the second series, the preoperative diagnosis was correct in almost 85 per cent of the cases, and operative results were favorable in 66 per cent of the cases, a considerable improvement in both respects over the first series.

Nine tables.

Infected Intervertebral Disk After Lumbar Puncture. L. L. Bromley, J. Donaldson Craig, and A. W. Lipmann Kessel. Brit. M. J. **1:** 132–133, Jan. 22, 1949.

The authors report a case of intervertebral disk infection which they attribute to injury incurred during lumbar puncture. At the age of twelve (in 1943) the patient had an attack of meningitic meningitis, and at least one lumbar puncture was done. Backache had been present at intervals since that time. Two years later a tender fluctuant swelling developed in the left groin. This finally discharged pus; a sinus tract remained but yielded to massive doses of penicillin. Three years later, the sinus recurred and was explored. It was followed from the left groin to the right anterior superior iliac spine. The wound healed by first intention.

Roentgenograms of the lumbar spine showed destruction of the intervertebral disk between the bodies of L-3 and L-4, with irregular shallow bone destruction of contiguous surfaces of the adjacent lumbar bodies. There was no evidence of a paraspinal abscess. The roentgenologist was convinced that the lesion was not tuberculous and considered the appearance consistent with a pyogenic infection secondary to lumbar puncture.

The relationship of the abdominal wall abscess and sinus to the spinal lesion is not explained. No mention is made as to the status of the lumbar spine on either of the previous hospital admissions.

One roentgenogram. EDWARD E. LEVINE, M.D.
Dearborn, Mich.

Osteitis Pubis: Its Diagnosis and Treatment. Lawrence L. Lavalle and Frank C. Hamm. J. Urol. **61:** 83–90, January 1949.

Seven cases of osteitis pubis are presented, making a total of 48 cases now reported in the literature. The authors believe that the incidence of this disease is much greater than is indicated by the published reports.

Osteitis pubis is an inflammatory or atrophic disease of unknown etiology beginning in the symphysis and rapidly involving the pubic rami and even the ischia. It characteristically follows suprapubic incision for prostatectomy or other urinary bladder procedures. The disease is a distinct entity and takes a definite course. Though it is self-limiting under expectant treatment, a period of prolonged pain and disability lasting three to twelve months has heretofore been the rule.

In a typical instance the patient is suddenly seized with increasingly severe pain over the symphysis pubis three to seven weeks following uncomplicated suprapubic prostatectomy. Pain becomes so excruciating with movement of the hips or trunk that it is bearable only on lying quietly in bed. A low-grade fever with some leukocytosis and secondary anemia is usually present.

The etiology of this complication does not seem to be related to surgical technic or to infection. Periostitis of the pubic bone is the earliest change, often followed by partial or complete destruction of the cartilage of the symphysis, with wide separation of the pubic bones. Bony destruction and absorption are followed by bony tissue replacement. Periosteal bone formation may result in spurs and complete ossification of the symphysis.

Positive roentgen findings may not be present for one to nine weeks after onset of symptoms. Films should be exposed at weekly intervals to confirm the diagnosis. The destructive changes in the pubic bones simulate lytic metastatic processes or inflammatory involvement. Dense calcification, spur formation, and ossification of the symphysis are indicative of healing.

On the presumption that osteitis pubis is a trophic disease such as polyneuritis, the authors used high doses of oral and intravenous vitamin B and short wave diathermy to the affected areas as soon as symptoms appeared. This treatment relieved pain in all but one patient in less than a week. X-ray therapy was successful in the single refractory case. Sulfonamides and penicillin were of no value.

Eleven roentgenograms. ALLAN K. BRINEY, M.D.
University of Pennsylvania

Osteitis Pubis. Robert S. Hotchkiss, Carl W. Schoenau, and Albert B. Accettola. New York State J. Med. **49:** 193–196, Jan. 15, 1949.

Osteitis pubis is a rather rare complication of prostatectomy but a serious one. It has been described, also, following herniorrhaphy, trauma, pyelonephritis, prostatic abscess, and difficult labor.

Symptoms are severe local pain, especially on adduction or rotation of the thigh, and tenderness on pressure. The temperature is usually elevated; there are debility and weight loss.

X-ray findings at first are negative: later there is fraying of the periosteum, followed by rarefaction and decalcification of the pubis and ischial bones. The findings at this point may suggest metastatic disease, but the diagnosis is established by diastasis of the symphysis, the development of osteophytes at the muscle attachments, and the replacement of the rarefied areas by new bone.

Four cases are reported in detail with good illustra-

tions. The authors believe that the incidence is higher than the literature indicates but fail to give the total number of prostatectomies from which their cases of osteitis pubis were drawn.

Seven roentgenograms. ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Ossification of Coracoclavicular Ligaments. Francesco Paroni. Ann. radiol. diag. **21:** 106–117, 1949. (In Italian)

The author discusses two cases of ossification of the coracoclavicular ligaments and concludes that this condition is almost always caused by trauma and very frequently follows acromioclavicular dislocations.

Seven roentgenograms; 1 drawing.
CESARE GIANTURCO, M.D.
Urbana, Ill.

Intrathoracic Dislocation of the Humerus. Esmond F. West. J. Bone & Joint Surg. **31-B:** 61–62, February 1949.

The author reports an unusual dislocation of the humerus as the result of striking the outstretched arm against a plank in the course of a vertical fall. Roentgenograms showed the head of the humerus displaced from the glenoid cavity and lying inside the thoracic cavity, gripped between the third and fourth ribs. A large fragment had been avulsed from the greater tuberosity and remained in approximately normal position. The dislocation was reduced quite easily, and a full range of rotation was restored.

Two roentgenograms.

Retrosternal Dislocation of the Clavicle. John C. Kennedy. J. Bone & Joint Surg. **31-B:** 74–75, February 1949.

A case of retrosternal dislocation of the clavicle is reported. Dislocation of this type may occur as a result of either direct or indirect violence. The history is of importance in reaching a diagnosis, but confirmation is obtained by roentgen examination, which should include oblique projections, stereograms, and laminagrams. Operative reduction and reconstruction of the extra-articular ligaments constitute the most reliable treatment.

One roentgenogram.

Cancer, Gumma and Tuberculosis of the Forearm. Nelson C. Jefferson. Am. J. Surg. **77:** 260–265, February 1949.

Three cases are presented, each with symptoms of pain and swelling of the forearm and each showing osteolytic lesions of the forearm. The author draws the conclusion from a study of these cases that, while roentgenography is no doubt the best clinical diagnostic aid, yet bone lesions may present unusual configurations which may be misleading.

In the first case, a 2-cm. osteolytic lesion in the distal end of the right ulna was diagnosed as chondrosarcoma or tuberculosis. Biopsy revealed tuberculosis.

The second case showed an osteolytic lesion of the middle third of the shaft of the radius. A clinical diagnosis of Ewing's sarcoma or endothelioma was entertained. A biopsy specimen was reported as showing typical normal thyroid tissue without evidence of mitotic figures or anaplasia. Further x-ray studies revealed osteolytic generalized lesions in the skeleton. Tissue from a thyroidectomy two years previously had been reported as benign, yet the tissues at necropsy revealed generalized metastatic thyroid disease.

In the third case an osteolytic lesion of the ulna was diagnosed clinically as bone sarcoma. Operation was refused and x-ray therapy was administered. Following this, a biopsy was secured and a microscopic diagnosis of osteochondrosarcoma was made. Further study indicated that the patient had had a laparotomy six years previously with biopsy of the liver reported as tuberculosis and also that the blood serology was positive for syphilis. Final review of the microscopic sections of the liver biopsy and the bone biopsy showed that both were actually gumma.

The author calls attention to the importance of x-ray examination, history, and accurate observations in resolving the sometimes conflicting opinions from any one of these procedures alone.

Nine roentgenograms; 6 photomicrographs.
MARLYN W. MILLER, M.D.
University of Pennsylvania

Stereoradiographic Reconstruction of Developing Carpus. R. O'Rahilly. Anat. Rec. **103:** 187–193, February 1949.

A radiopaque reconstruction of the developing carpus was made and investigated by stereoradiography. The technic is given in detail. The appearance of the hand in a 17 mm. C. R. human embryo is described and a comparison is made with recorded cases. It is concluded that "there is considerable variation in the early development of this region and that the lunate and pisiform are usually the last carpalia to develop. The close association of the developing trapezium and first metacarpal is confirmed."

Two roentgenograms; 1 tracing; 1 photomicrograph.

Cough Fracture of Ribs. Raymond C. Cohen. Brit. M. J. **1:** 133–135, Jan. 22, 1949.

The author reports 7 cases of fractured ribs, apparently occurring "spontaneously." All were in patients with pulmonary tuberculosis. There was usually a clear history of pain following violent coughing or sneezing.

The mechanism of such fractures is difficult to determine. They are probably associated with asymmetrical posture, producing uneven action on the ribs. Prolonged bed rest, with the incident mild degree of decalcification, may be a contributory factor.

Three roentgenograms.
EDWARD E. LEVINE, M.D.
Dearborn, Mich.

Cough Fracture in Late Pregnancy. J. W. Paulley, D. H. Lees, and A. C. Pearson. Brit. M. J. **1:** 135–137, Jan. 22, 1949.

Brief histories of 4 cases of fractured ribs, chiefly on the left side, seen late in pregnancy, are reported. All occurred during "coughing fits."

Suggestions are made as to the mechanism of the condition. Bone fragility is almost disregarded as a contributing factor. The authors consider as more plausible the theory that the fractures are due to a mechanical cause peculiar to the protuberant abdomen and the compensatory body lordosis.

Two roentgenograms. EDWARD E. LEVINE, M.D.
Dearborn, Mich.

Premature Epiphysial Fusion at the Knee Joint in Tuberculous Disease of the Hip. W. Parke, G. S. Colvin, and A. H. G. Almond. J. Bone & Joint Surg. **31-B:** 63–73, February 1949.

A review of 91 cases of tuberculous disease of the hip was undertaken to determine the incidence of premature epiphyseal fusion at the knee joint and the changes which precede and accompany it. In all cases the disease had its onset before fifteen years of age; the duration varied from four months to twenty-two years.

Premature fusion is always preceded by intense osteoporosis of the bones of the knee. The earliest stage is marked by triangular areas of radiolucency in the diaphysis and epiphysis with their apices at the point of entry of the nutrient artery and their bases on the articular cartilage. With further resorption of the bone, there is loss of transverse trabeculation and the diaphyses take on a frosted-glass or honeycomb appearance. The cortical bone on the affected side shows thinning, and the vertical depth of the epiphyseal plates is reduced.

The authors describe two types of fusion, the "bulge type" and the "fragmentary type." The "bulge type," occurring in the tibial epiphysis, is first seen as a central translucent area appearing on the inner side of the mid-line above the point of strut decussation. This translucent area enlarges upward toward the articular cartilage and downward toward the terminal bone plate. The terminal bone plate, the thinned cartilaginous plate, and the growth retardation line, together with the medullary contents of the shaft, then bulge upward into this translucent area. This may be termed a prefusion stage. Premature fusion is inevitable when the limiting structures of the bulge rupture. This allows the semi-fluid medullary contents of the epiphysis and diaphysis to intermingle, and a channel is established through which the blood supply of both can become continuous.

The "fragmentary type" of fusion occurs more frequently in the femur and is preceded by intense osteoporosis. Central translucent areas appear in the diaphysis and epiphysis. Subcortical absorption occurs on the peripheral aspect of the vertical cancellous struts and does not abut to any extent on the terminal bone plate. Premature fusion is indicated by the appearance of many small isolated fragments of calcific material replacing the crenated line of the terminal bone plate, which is normally well defined and continuous.

Among the 91 tuberculous hips reviewed, there were 29 instances of premature fusion at the ipsilateral knee. These were divided into (1) late fusions, 15 cases, all with a bone lock between epiphysis and diaphysis; (2) early fusions, 8 cases, with ruptured bulges or fragmentary changes; (3) doubtful fusions, 6 cases, with unruptured bulges or fragmentary changes with uncertain evidence of destruction of the cartilaginous plate.

In 27 cases the tuberculous hip disease was of less than two years duration and in none of these was there evidence of premature fusion. Of 36 patients with a three- to five-year history of the disease, all but 1 showed doubtful or early fusion. Of the 21 cases lasting from six to ten years, there were 9 with evidence of late epiphyseal fusion and no examples of early or doubtful fusion. Every one of the 7 patients with a history of more than ten years showed premature fusion.

There is a close relationship between premature fusion at the knee and the severity of the hip disease. The more severe the disease, the more likely premature fusion.

The authors feel that the fundamental factors responsible for the bone changes are toxemia from the infection at the hip and prolonged immobilization, existent for not less than two years.

No cases were found in this series showing premature fusion of the upper fibular epiphysis. The explanation may be the late appearance of the ossific nucleus of the fibular head or the fact that the surface area of the epiphyseal plate is so small and the shaft so slender that such loss of trabecular support as does occur is insufficient to weaken this area of cartilage to the point of rupture.

Twenty roentgenograms; 3 tables.

JOHN R. HODGSON, M.D.
The Mayo Clinic

Unicameral Cyst of the Calcaneus. Robert G. Dunn, Jr. Virginia M. Monthly **76:** 30–31, January 1949.

Solitary cyst of the calcaneus is a rare condition, with 16 cases reported. To these the author adds 2 more. Clinical signs and symptoms may or may not be present. Roentgen findings, however, are typical. A triangular area of radiolucency is seen in the anterior portion of the os calcis. Frequently a multilocular appearance is noted and fine trabeculations may be seen crossing the cyst. There is lateral expansion of the cortex, which remains intact, as in the solitary cyst of the long bones. No periosteal changes are present, and there is no destruction of the bone.

Two roentgenograms.

THE GENITO-URINARY SYSTEM

True Right Supernumerary Kidney Diagnosed Preoperatively. Charles Montgomery Stewart. J. Urol. **61:** 327–332, February 1949.

A single case of a true supernumerary kidney diagnosed preoperatively is presented. Its interest lies in the fact that it is the fourth such case to be diagnosed preoperatively. It brings the total number of cases on record to 49.

The chief complaint was lower abdominal mid-line pain, usually following lifting or straining during bowel movements. An intravenous urogram revealed a normal left kidney but a smaller than normal right kidney with a rudimentary type of pelvis and calices. The small right kidney lay at a higher level in the abdomen than the left. Cystoscopy revealed two ureteral orifices on the right side. Urine and indigo carmine appeared from the lower orifice, but nothing came from the upper. Retrograde pyelography showed that the upper ureteral orifice led to a dilated pelvis and calices of a kidney separate from the one which was demonstrated on the intravenous urogram, located to the right of the spine just above the right sacroiliac joint.

Transperitoneal removal of this supernumerary kidney was carried out, with an uneventful postoperative course. The gross specimen consisted of a kidney which together with the pelvis measured 7 cm. in its greatest dimension. The pelvis was dilated and largely extrarenal. Histologic examination showed areas of interstitial fibrosis in the tips of the renal pyramids and subintimal hyaline fibrous thickening of the glomerular

capillaries. *Diagnosis:* Hydronephrosis of a supernumerary kidney.

Six roentgenograns; 1 photograph.

JOHN W. HOPE, M.D.
University of Pennsylvania

An Unusual Renal Anomaly: Combined Tandem and Horseshoe Kidney. Phillip B. Potampa, Milton D. Hyman, and Charles E. Catlow. J. Urol. **61:** 340–343, February 1949.

The authors present a case of a renal anomaly not previously described in the literature, proved by both retrograde pyelography and surgery. An elongated left kidney was divided into a superior and inferior portion connected by a fibrous band. The superior portion was drained by a normal left ureter. The inferior portion was continuous across the mid-line to the right kidney and shared a common pelvis with the right kidney. This common pelvis was drained by the right ureter, having a normal bladder relation but swinging over across the mid-line to drain the common pelvis on the left side at the inferior portion of the left kidney. Embryologically, such an anomaly could be explained by a fusion of the ureteral buds across the mid-line before they grew up to meet the renal masses, with the left ureteral bud breaking away later on to form the ureter and pelvis of the superior component of the left kidney.

The patient with this anomaly presented himself because of pain and swelling in the left flank associated with a staghorn calculus in the left superior renal pelvis and pyelonephritis on the left. There were no signs of impaired kidney function, and the response to surgical and medical treatment for the calculus and pyelonephritis, respectively, was good.

Three roentgenograms; one diagram.

PAUL W. HOFFERT, M.D.
University of Pennsylvania

Crossed Unfused Renal Ectopia with Tumor. Harry P. Lee. J. Urol. **61:** 333–339, February 1949.

Crossed unfused renal ectopia is one of the rare congenital anomalies of the urinary tract. The ureters arise from their normal positions in the bladder but the ureter to the misplaced kidney crosses the mid-line in its ascent to enter the renal pelvis. Of all the cases of crossed kidneys, it is estimated that only 1 in 10 remains unfused with its normal mate.

The author reviewed the literature and found 28 cases in which he feels that the diagnosis of crossed unfused ectopia was correct. He contributes a twenty-ninth case. The left kidney was crossed in 21 cases and the right in 7; in 1 case both kidneys were crossed. The condition occurred 19 times in males and 10 in females. In 27 cases the crossed kidney lay under the uncrossed one. On 12 occasions the diagnosis was made on the basis of surgical findings, on 13 at autopsy or in the cadaver; in 4 cases a pyelographic diagnosis was made. Attention has frequently been called to the condition by the occurrence of infection, hydronephrosis or calculus in the crossed kidney. In 3 cases the misplaced organ was the site of a tumor: in 2 adenocarcinoma and in the author's case a primary squamous-cell carcinoma apparently arising in the renal pelvis.

With improving technics, resulting in better visualization of the kidney shadows, diagnosis by roentgen methods should be made with greater accuracy. Those cases in which the normally placed kidney is well visualized and the crossed kidney is far enough away so that the two can be distinguished should lend themselves to roentgen diagnosis. Attempts have been made to show lack of fusion by fluoroscopic methods, but the results are inconclusive where the kidneys are close together. A unilateral ectopic kidney with a short ureter which lies in front of the sacrum with portions of the cortex and pelvis on either side of the mid-line is regarded as uncrossed ectopia by the author.

Two roentgenograms; 1 photomicrograph; 1 table.

DANIEL TALLEY, III, M.D.
University of Pennsylvania

Normal and Abnormal Micturition: A Study of Bladder Behavior by Means of the Fluoroscope. S. Richard Muellner and Felix G. Fleischner. J. Urol. **61:** 233–241, February 1949.

The authors by direct observation of the act of micturition, fluoroscopically, have given the first really physiologic exposition of this process and completely refuted the present concepts in relation to this function. The bladder was filled with contrast medium (200 c.c. of 5 per cent sodium iodide plus one ampule of 35 per cent aqueous diodrast) and the subject was examined in the erect position with fluoroscopy and spot films during the various phases of micturition.

By such methods the direct voluntary control of urination in man is seen to center in the muscles of the pelvic floor, principally the pubococcygeus, aided by the diaphragm and abdominal musculature to increase intra-abdominal pressure.

When the subject is asked to void, the bladder base is pulled sharply downward into a point. This pulls the internal sphincter downward and very shortly thereafter detrusor contraction begins. As micturition proceeds, the internal sphincter gradually rises until it again lies just above the symphysis when the bladder is empty. Voluntary cessation of urination is accomplished by a similar leveling of the bladder base occurring much more suddenly.

The fluoroscopic findings in various disease processes involving abolition of the voluntary mechanisms as a result of infiltration of the bladder base or paralysis of the pelvic floor are described. It is clearly demonstrated that all such events result in automatic micturition or cord bladder. Therefore, cord bladder is not specific to a particular nerve lesion as previously believed.

The importance of these findings in the management of patients who have lost voluntary control of urination is evident.

Five illustrations.

N. F. ZIMMERMAN, M.D.
University of Pennsylvania

The Etiology of Stress Incontinence. S. Richard Muellner. Surg., Gynec. & Obst. **88:** 237–242, February 1949.

The author has attempted to shed some light on the actual mechanism of incontinence following parturition. Feeling that cystometry, cystography, and urethrography were inadequate, he filled the bladder with contrast medium and observed the patient fluoroscopically in supine, standing, and oblique positions. [The technic seems to be similar to that described in the preceding abstract.] Spot films were made of significant events. The effects of coughing and straining and starting and stopping the urinary stream were

evaluated. A special plastic urinal was devised that would not cast a roentgen shadow, and this device is illustrated. Controls consisted of continent women.

The precise mechanisms are described in both the normal and the incontinent women. In the normals the bladder base, and especially the region of the internal sphincter, is in close relationship to the muscles of the pelvic floor. These muscles play a very active part in the initiation and inhibition of the urinary stream. When the continent woman stands up, they form a firm support for the internal sphincter and not only take on the added gravitational strain induced by the erect posture but also take up any additional sharp increase in intravesical pressure which may result from exertion, coughing, or sneezing, and thus protect the internal sphincter from these stresses.

The important muscles of the pelvic floor performing this function are the pubococcygeus portion of the levator ani and, to a much lesser extent, the transverse perinei muscles. These muscles are responsible for the descent of the internal sphincter at the start of micturition, and they sharply lift the bladder base up to shut off the stream. It is the descent and the opening of the internal sphincter which initiate the reflexes of micturition. The effects of gravity and increased intra-abdominal pressure in pushing the bladder down are emphasized.

In the women with exertional incontinence, in the downward excursion of the bladder, the region of the internal sphincter takes up most of the thrust and yields even more than the base. In the erect posture the bladder base descends as a whole, but it is specifically the region of the internal sphincter which descends most, with the base assuming the "pointed" appearance characteristic of the bladder poised for micturition. It then takes only a little additional descent to open the sphincter and allow the jet of urine to escape. The principal fault in the incontinent is the specific lack of support in the region of the internal sphincter, which allows the sphincter to become dependent when the patient stands up but not when she is recumbent.

It is further explained that in the women who, once the urinary stream is involuntarily initiated, completely empty their bladders, the supports of the internal sphincter do not possess sufficient tonicity to lift the bladder base and thus inhibit the urinary stream.

Two cases of urinary incontinence in nulliparous women were studied and found to have a mechanism identical to that in multiparae. It is conjectured that the muscular weakness in these was probably congenital.

Thirteen roentgenograms; 5 diagrams.

PAUL W. EYLER, M.D.
University of Pennsylvania

Metastatic Carcinoma of the Ureter in Carcinoma of the Cervix. Leo S. Drexler. Am. J. Obst. & Gynec. **57:** 392–395, February 1949.

It has long been recognized that ureteral obstruction with renal infection and uremia is a common cause of death in carcinoma of the cervix. Many authors argue that fibrosis of the lower ureter follows radiation therapy, but this process of desmoplasia can occur in the absence of radiation therapy. Involvement of the ureter itself is rare. Rather, the tumor spreads to the surrounding lymphatics and, in turn, causes ureteral obstruction by compression.

The authors discuss a single case of carcinoma of the cervix in which metastasis to the ureter was discovered by operation. This patient had received 9,000 mg. hours of radium, in two doses, administered by uterine tandem with colpostat and cork. This was followed by 6,600 r of deep x-ray therapy. On subsequent examination a non-functioning kidney was discovered by urography and cystoscopy. At operation, the proximal ureter was found to be replaced by solid tumor formation which proved to be metastatic squamous-cell carcinoma of the ureter of uterine cervical origin.

This is the only case in the institution from which the report comes in which metastasis to the ureter has been discovered since 1933.

Two roentgenograms; 3 photomicrographs.

ROBERT H. LEAMING, M.D.
Jefferson Medical College

On the Roentgen Aspect of Prostatic Atrophy. Nils P. G. Edling. Acta radiol. **31:** 145–151, Feb. 28, 1949.

To evaluate the significance of a localized luminal widening of the prostatic urethra, the author studied the radiographic changes and clinical records of 41 cases showing this phenomenon. In 35 of the cases there was clinical or roentgen evidence of prostatitis. In none was there any deformity typical of hypertrophy or cancer.

In most cases, the widening is described as limited to the region just above the collicle, the rest of the supracollicular urethra and the infracollicular urethra being normally contracted. In a few cases, the whole prostatic urethra is dilated, forming a stiff tube with an associated small fibrotic bladder. Open ureteral orifices and dilated ureters may be found.

Textbooks of pathology describe prostatic atrophy as causing dilatation of the urethral lumen and shrinkage of the collicle, the most common type being due to inflammation or senility. Pathologically, there is a decrease in the muscular and glandular tissue, and an increase in the fibrous tissue, resulting in shrinkage.

Ten roentgenograms. R. L. MASON, M.D.
Cleveland Clinic Foundation

THE ADRENALS

Pheochromocytoma of the Adrenal with Successful Removal. Report of a Case. A. L. Forsgren, W. D. Nesset, and D. M. Anderson. Minnesota Med. **32:** 170–174, February 1949.

Approximately 70 cases of pheochromocytoma of the adrenal diagnosed preoperatively have been reported. The authors present a typical example with the syndrome of paroxysmal hypertension.

A 27-year-old male complained of attacks of weakness, flushed sensation, palpitation, headache, and nervousness over a period of four years. The blood pressure was mildly elevated; on one occasion it reached 225/140. All routine laboratory procedures, including basal metabolism tests and electrocardiogram, were within normal limits. A histamine tolerance test was strongly suggestive of an adrenal tumor. A cold pressor test showed a normal response. Roth and Kvale have emphasized the importance of contrasting the histamine test with the cold pressor test, since patients with essential hypertension may exhibit a pressor effect following histamine which is approximately similar quantitatively to their response to the cold pressor test. Tetraethylammonium chloride in-

jected intravenously sometimes precipitates a paroxysm of hypertension. In this case it did not.

Roentgenograms following injection of 600 c.c. of air into each perirenal space showed a globular mass overlying the upper pole of the left kidney. An intravenous pyelogram had failed to disclose this tumor.

A diagnosis of pheochromocytoma of the adrenal was made and a well encapsulated tumor weighing 66 gm. and 5 cm. in diameter was removed. Histopathologic study confirmed the diagnosis.

One month after operation, the patient was discharged. The histamine tolerance test was normal and the blood pressure had averaged 120/75 during the preceding week.

Removal of a pheochromocytoma promises a cure in all but a few cases. Sometimes a second operation may be necessary for removal of additional tumor tissue. The great majority of pheochromocytomas are benign, but malignant changes do occur, chiefly in bilateral tumors.

Six illustrations, including 3 roentgenograms.

W. H. ROBINSON, M.D.
Cleveland Clinic

TECHNIC

Demonstration of Sinus Tracts, Fistulas, and Infected Cavities by Lipiodol. James M. Dell, Jr. Am. J. Roentgenol. **61:** 223–231, February 1949.

The purpose of this paper is to present the technic of lipiodol injection for the demonstration of sinus tracts, fistulas, and infected cavities. The information gained by this procedure can furnish the surgeon with useful information as to the extent and direction of the disease process.

The first requisite is that the injecting mechanism be tightly applied to the walls of the tract. To accomplish this, the author has devised several adaptors. For the smallest openings a No. 20 gauge needle with the shaft cut off near the base is used; for slightly larger openings, the shaft is pulled out of the base. Other adaptors are improvised from the stoppers of standard rubber-capped vials and from the rubber caps of medicine droppers. Finally catheters of increasing size may be used. When a tract has multiple openings, several or all but one of these may need to be plugged or sutured.

The quantity of lipiodol required may be closely estimated by the amount of drainage from the tract. For injection of the first cubic centimeter, the author does not hesitate to employ rather marked pressure to overcome the effect of numerous small plugs which may exert a ball-valve action or block the opening. Later, undue pressure should be avoided. The problem of retention of the medium may be met by having the patient hold the syringe or place a gauze-covered finger over the opening as the injecting mechanism is removed.

Stereoscopic roentgenograms are imperative in complicated tracts. To these should be added a film made at a right angle to the stereoscopic projection. Oblique views are sometimes necessary but anteroposterior and lateral views are usually adequate.

In the author's series of 150 cases, complications occurred in only 3, and these were of minor importance. The only contraindication to the procedure is an acute or a subsiding acute inflammatory process associated with the tract.

It is believed that any draining sinus of more than a month duration should be studied by this procedure in order that proper surgical treatment may be instituted.

Twenty-one roentgenograms.

D. GASTINEAU, M.D.
Indiana University

Standardization of Apparatus as Affecting Radiological Interpretation. C. E. Eddy. M. J. Australia **1:** 208–209, Feb. 12, 1949.

This is a short article dealing mainly in generalities about the qualities of an "ideal" radiograph of the chest and means of reduplicating its quality by standardizing equipment. Manufacturers are taken to task for introducing features which make their product more saleable rather than cooperating with one another and with radiological organizations to produce the best machine possible.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Conjunctival and Skin Tests in the Employment of Iodine Salts as Contrast Media. Gustaf Notter. Acta radiol. **31:** 60–64, Jan. 31, 1949. (In German)

On the basis of 100 cases in which intracutaneous and conjunctival tests were done prior to intravenous urography, arthrography, and myelography with water-soluble iodine compounds, the authors state that the conjunctival test is of questionable value. They found the intracutaneous test to be superior but conclude that neither is reliable. An example of a severe anaphylactic reaction despite negative preliminary testing is cited.

Reference is made to the papers of Archer and Harris and of Robins (Am. J. Roentgenol. **48:** 763, 766, 1942. Abst. in Radiology **41:** 99, 100, 1943).

SAMUEL MORCHAN, M.D.
Indiana University

RADIOTHERAPY

Retinoblastoma (Retinal Glioma) Cured by Radon Seeds. Report of a Case. Joseph Waldman and C. E. G. Shannon. Arch. Ophth. **41:** 32–41, January 1949.

The cure or arrest of retinoblastoma by any method of treatment is rare. The authors' patient had a histologically confirmed retinoblastoma of one eye (enucleated) treated and observed for twelve years and retinoblastoma of the remaining eye cured for a period of nine years.

Enucleation of the left eye was performed in January 1935, when the patient was ten months of age. The optic nerve was microscopically free of tumor cells. Two months later, radium therapy, 50 mg. in a small pack, was applied to the left temple for thirty minutes. Five applications of radon seeds in a special holder and 1 radon seed embedded in dental stent, for a total of 3,760 millicurie hours, were administered between November 1938 and May 1942.

The right eye was found to be involved in 1938 and was given roentgen therapy, with the following factors: 200 kv.; 50 cm. distance (laterally) to the temporal side; filter, 0.5 mm. of copper and 1 mm. of aluminum. The first treatment was 64 r, and each treatment thereafter

160 r, for a total of 1,504 r (May–June 1938). In 1939, a second series, of 1,600 r, was given. In November 1938, 2.5 millicuries of radon was applied in dental compound and sewed to the overlying sclera. Five applications of radon seeds were administered from March 1939 to May 1942.

At the time of the report the patient was thirteen and a half years old and attending a sight-saving school. Visual acuity in the right eye was 6/60. Typical irradiation cataract and changes in the fundus, probably incidental to radon therapy, were present.

The authors endorse the procedure of Martin and Reese for the treatment of retinoblastoma (Arch. Ophth. **16:** 733, 1936; Arch. Ophth. **27:** 40, 1942): (1) for unilateral ocular involvement, prompt enucleation with as long a section of the optic nerve as possible and frequent ophthalmoscopic examinations for five years; (2) for bilateral involvement, prompt enucleation of the more diseased eye and radiation therapy, with the idea of saving life and conserving vision in the remaining eye if the growth is not too far advanced and the specialized technic of fractionated roentgen therapy is available.

The local use of radon is recommended as another form of treatment of retinoblastoma, particularly when the exact and careful technic of fractionated roentgen therapy is not available.

Five illustrations, including 1 roentgenogram.

Carcinoma of the Cervix—Review of 100 Cases. Everett M. Baker. South. Med. & Surg. **111:** 29–36, February 1949.

This paper is based upon a review of 100 cases of cervical carcinoma from the Tumor Clinic of the Elizabeth Steel Magee Hospital, Pittsburgh. Among the points brought out is the importance of a complete work-up of the case prior to treatment, especially with respect to the urinary tract. Hydroureter and hydronephrosis are said to occur in about 70 per cent of cases, from scar tissue or tumor encroachment or infiltration.

In the series here recorded, surgery, radium, and external and intravaginal roentgen therapy were employed in various combinations according to the indications in each case. Radium was not used interstitially. The presence of pelvic inflammatory disease is a contraindication to the employment of radium. External roentgen therapy is the procedure of choice for tumors of Groups II, III, and IV under these circumstances.

Survival rates were comparable to those in most published series. Tables are given analyzing the cases according to age, stage, form of therapy, histology, parity, duration of symptoms, and incidence of complications.

Eleven tables.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Malignant Tumors of the Uterine Fundus Subsequent to Irradiation for Benign Pelvic Conditions. Harold Speert and Thomas C. Peightal. Am. J. Obst. & Gynec. **57:** 261–273, February 1949.

In an analysis of 270 patients treated for malignant uterine fundal tumors, the authors discovered that 21 of these patients had had previous pelvic irradiation for benign conditions. The question to which they seek an answer is whether pelvic irradiation influences the subsequent development of neoplastic disease of the uterine fundus. In their series the average interval between irradiation and detection of the uterine cancer was 8.3 years.

Six of the 21 tumors contained sarcomatous elements, which is five times the incidence of sarcoma among all the malignant tumors of the uterine fundus.

The incidence of previous pelvic irradiation among patients with cervical carcinoma was 0.3 per cent in contrast to 8.0 per cent in patients with malignant tumors of the uterine fundus.

The authors review the previously published cases in addition to the 21 cases now presented.

Six photomicrographs; 1 table.

ROBERT H. LEAMING, M.D.
Jefferson Medical College

Diagnosis and Management of Fundal Carcinoma. Lewis C. Scheffey. South. M. J. **42:** 44–52, January 1949.

Carcinoma of the fundus is comparatively rare before forty years of age. It is most commonly seen after the menopause, in women past fifty. Symptoms usually include some type of irregularity of menstruation or "spotting" in the postmenopausal patient. Uterine fibroids are present concomitantly in 25 to 50 per cent of cases.

In addition to diagnostic curettage and biopsy, the author stresses the value of the Papanicolaou vaginal smear technic as a screening procedure in diagnosis of this condition.

Before the wider implications of total hysterectomy were appreciated, the supravaginal technic was used frequently, but with the development of diagnostic curettage total hysterectomy and adnexal removal became the procedure of choice. With the advent of radium and x-ray therapy in cervical cancer, these agents became widely and often exclusively used for fundal lesions, especially in poor-risk patients, and to some extent in good-risk patients as well. As the deficiencies of this technic became apparent, there was a tendency to use surgery and irradiation conjointly, with better results than either alone. This combined method has become the author's usual procedure; he uses preliminary irradiation, followed in suitable cases by surgery essentially as practised in most large modern gynecological clinics today.

The author's procedure in a suitable candidate who has had bleeding but no demonstrable cervical lesion, and whose uterus is not markedly enlarged, fixed, or irregular in outline, is as follows: A diagnostic curettage is performed, then, barring contraindication, two or three radium capsules of 50 mg. each, screened with 1.5 mm. of platinum, 2.5 cm. in "active length" and 1.5 mm. in diameter, are placed in the uterine cavity. The curettings are sent to the laboratory for immediate preparation of sections, which are available in four hours. If the tissue is malignant, the radium is left in place for a total of 5,000 mg. hours, and in six to ten weeks total hysterectomy and salpingo-oophorectomy is performed. If no cancer is present, the radium is removed when a sufficient hemostatic dose has been delivered. Postoperative irradiation is used only when there is obvious extension or metastasis at operation.

In cases with too tortuous or too distorted uterine cavities to permit insertion of radium, either of two procedures is done. First, if adequate curettings are obtained, nothing more is done until the pathologist's report is received in twenty-four to thirty-six hours. If malignancy is shown, preliminary irradiation is used,

followed by surgery. Second, if only moderate or minimal currettings are obtained, immediate surgery may be done, frozen section examination being the determining influence as to the extent of the surgical procedure.

In management of the poor-risk patient, intrauterine radium therapy is the method of choice, external x-radiation being used when radium within the uterus cannot be utilized.

Most of the author's irradiation has been given with the tandem (50 mg. capsules), but he has recently been using, in some cases, multiple smaller units of radium in uterine cavities sufficiently large to accommodate them.

Two hundred and fourteen patients have been treated for fundal carcinoma under the author's supervision between 1921 and 1948. The follow-up is 100 per cent. The lesion was limited to the uterus in 74 per cent of these cases. The over-all five-year survival rate is 55.8 per cent.

HARVEY J. THOMPSON, JR., M.D.
Jefferson Medical College

Treatment of Carcinoma of the Body of the Uterus. Braithwaite Rickford. J. Obst. & Gynaec. Brit. Emp. **56:** 41–45, February 1949.

This paper presents a review of the literature and a follow-up study of 136 cases of carcinoma of the body of the uterus, of which 101 were treated initially by panhysterectomy only, 20 by radium alone, and 2 by x-rays alone. In 5 cases hysterectomy was preceded by radium therapy.

The five-year survival rates reported by American writers for preoperative radiation are tabulated as follows:

	No. of Cases Treated	Survival Per Cent
(*a*) For Preoperative Radium Therapy Followed by Hysterectomy		
Healy and Brown (1939)	28	75.0
Corscaden (1944)	25	72.0
Scheffey et al. (1946)	10	90.0
Miller and Henderson (1946)	16	86.6
Taylor and Becker (1947)	31	64.5
(*b*) For Preoperative X-Ray Therapy Followed by Hysterectomy		
Miller (1940)	24	70.5
Miller and Henderson (1946)	96	77.0
Taylor and Becker (1947)	13	38.5

The author's own results with hysterectomy are also given:

Total number of cases	101
Alive and well after five years	54
Alive with disease	8
Lost	18
Absolute five-year cure	53.4 per cent
Relative five-year cure	65.1 per cent
Relative five-year survival	74.7 per cent

With radium alone, the absolute five-year survival rate was 15 per cent and the relative five-year survival 20 per cent.

It is concluded that the most rational treatment is primary operation if the patient is considered fit, with certain precautions to reduce the risk of late metastases in the vaginal scar, including radium implantation or roentegn therapy to deal with any scattered cancer cells. For the "technically operable" case in which for any reason surgery is contraindicated, Heyman's method of packing the uterus with radium is the treatment of choice.

Five tables.

S. F. THOMAS, M.D.
Palo Alto, Calif.

Influence of Tumour Histology, Duration of Symptoms and Age of Patient on the Radiocurability of Cervix Tumours. M. Gilmour, A. Glücksmann, and F. G. Spear. Brit. J. Radiol. **22:** 90–95, February 1949.

The end-results in 776 patients with cervical carcinoma treated by the Stockholm technic at the Marie Curie Hospital, London, were studied. Only those cases were included to which complete treatment was given.

First the cases were classified according to tumor type, as anaplastic, squamous-cell (differentiating), and columnar-cell. The results confirmed the belief that, for the same clinical stage, more of the differentiated tumors responded well than of the anaplastic. On classifying the cases according to the age at which they were first seen, it was found that the incidence of differentiated tumors increased with advancing years. The survival rate shows a slight increase with age but not enough to be statistically significant.

The duration of symptoms seemed to have no bearing on the outcome of radiotherapy. Survival rates in Stages 1 and 2 and Stages 3 and 4 did not vary significantly with duration of symptoms. Interestingly enough, survival rates in differentiating tumors increased with increase in the duration of symptoms. This indicates that the clinical extent of the disease depends upon the rate of growth of the tumor as well as the duration.

Four tables.

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Extravesical Radium Therapy in Cancer of the Bladder. R. Ogier Ward. Brit. J. Urol. **20:** 191–202 December 1948.

A new technic for radium therapy of cancer of the bladder is described, the essential feature of which is that the needles are placed in position in the outer layers of the bladder wall corresponding to the growth, without the performance of cystostomy and without penetration of the bladder cavity. Careful preliminary investigations and accurate cystoscopic examination are essential.

Five cases are reported, in 2 of which extensive highly malignant growths disappeared and the patients were free of symptoms nine months and four months after treatment. Two patients died. In the fifth case, a large portion of the growth within the bladder was destroyed, but the extravesical part was little affected and has since increased in size.

The author makes no excessive claims for this method but hopes that this report will encourage others to try the procedure.

One roentgenogram; 4 drawings.

Pregnancy and Hodgkin's Disease, with a Report of Three Cases. S. Chas. Kasdon. Am. J. Obst. & Gynec. **57:** 282–293, February 1949.

A thorough review of the literature concerning pregnancy and Hodgkin's disease is presented by the author, with a report of 3 additional cases. Through such an analysis an attempt was made to establish a basis for the satisfactory management of pregnancy in Hodgkin's disease.

Adequate shielding has prevented the occurrence of radiation injury to the fetus. If there is any tendency to exacerbation of the disease, it most likely follows delivery at term. There was a placental transmission to the fetus in 9 per cent of the reported cases.

Hodgkin's disease does not grossly affect ovulation, fertility, incidence of spontaneous abortion, or hemorrhage. It offers no indication for the interruption of pregnancy according to the evidence presented in this interesting article.

Two tables.

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Jefferson Medical College

Effect of Roentgenotherapy on Urinary 17-Ketosteroid Excretion in Ankylosing Spondylarthritis. Roland A. Davison, Peter Koets, and William C. Kuzell. J. Clin. Endocrinol. **9:** 79–88, January 1949.

Although ankylosing spondylarthritis is a chronic debilitating disease accompanied by malnutrition, anemia, and pronounced muscle wasting in its advanced stage, previous observations by the authors revealed an increased urinary 17-ketosteroid excretion in 13 males studied. Since roentgen therapy has been reported by others to exert a pronounced beneficial effect on the course of ankylosing spondylarthritis, giving relief of symptoms, abatement of objective physical findings, and improved well being even in advanced cases, further studies were made to determine the effects of the radiation on the 17-ketosteroid excretion.

The studies were made on 31 males and 4 females. X-ray therapy consisted of 6 daily treatments, this course being repeated in one month and again in three months. The cervicodorsal and lumbosacral areas were treated on alternate days with the following factors: 200 kv., 20 ma., 70 cm. anode skin distance, 1.0 mm. copper half-value layer, with fields averaging 15 × 8 cm.

Roentgen therapy seemed to provide a stimulus to increased 17-ketosteroid excretion, followed by a relative decrease. After roentgen therapy the values returned to high levels, although the symptoms and signs of the ankylosing spondylarthritis had abated.

Six charts; 1 table.

Roentgen Therapy of Rheumatoid Spondylitis. Nathan M. Spishakoff and B. V. A. Low-Beer. California Med. **70:** 124–129, February 1949.

An analysis of 125 cases of rheumatoid spondylitis treated at the University of California Hospital between 1942 and 1948 was made. At first, treatment was directed locally to the painful areas only, usually the region of the lumbar spine and sacroiliac joints. Later, moderately elongated fields, including the thoracic spine, were used, treatment being repeated only on recurrence of symptoms. Since 1944, the use of three or four relatively small fields extending along the entire spinal axis has been practised with an additional horizontally placed field to cover the sacroiliac joints. The uppermost field measures 10 × 10 cm., the others 10 × 15 cm. With rays generated at 200 kv.p., 1.05 mm. Cu h.v.l., 50 cm. target-skin distance, and an output of approximately 45 r per minute, 200 r (in air) are delivered to the upper and lower halves of the vertebral column and paraspinal musculature on alternate days for a total of 600 r (in air) per field. A second course is given after a period of four weeks and a third after a further rest period of twelve weeks.

The results obtained indicate that treatment to the entire spine in three courses with properly spaced rest periods is the most efficient in permanent relief of symptoms. In 6 (54.5 per cent) of 11 cases receiving only one course of irradiation, symptoms were not relieved or recurred. Similar failure to obtain relief or subsequent recurrence was observed in 13 (37.1 per cent) of 35 patients receiving two courses and in 10 (13.8 per cent) of 73 receiving three courses. All the patients treated locally suffered recurrences and were subsequently given treatments to the whole spine.

It is concluded that any active case of rheumatoid spondylitis warrants roentgen therapy regardless of the duration and severity of symptoms or the stage of the disease as indicated by the roentgenogram, since in even the most advanced cases the patient will probably be relieved of pain and muscle spasm, while increased motion of the spine and thoracic cage will be regained when fixation and ankylosis have not occurred, especially if irradiation is supplemented by orthopedic and general supportive measures.

Four illustrations; 3 tables.

MAURICE D. SACHS, M.D.
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Hidrosadenitis Axillaris and Its Roentgen Treatment (Optimum Total Dose and Intenseness). N. Lauge-Hansen and Svend Lyndrup. Acta radiol. **31:** 129–144, Feb. 28, 1949.

Various methods of treatment have been advocated for inflammation of the apocrine sweat glands of the axilla, including drainage, vaccines, etc. None has proved particularly efficacious in shortening the course, which may extend for months. The authors have used roentgen therapy, with the following factors: 128 kv., 6 ma., 40 cm. distance, 0.5 mm. Cu + 1.0 mm. Al filtration (or 3.0 mm. Al), and have attempted to find the optimum dose and intensity which will effect early regression and prevent relapse.

An analysis of 357 cases showed the optimum total dose to be 1,200 r, in doses of 200 r daily, 300 r every other day, or 400 r every third day. The average duration of the disease after institution of therapy was two weeks.

Six tables.

[An original paper by Schenck analyzing the results of roentgen therapy in 54 cases of hidradenitis axillaris appears elsewhere in this issue (p. 74).—ED.]

R. A. HAYS, M.D.
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Eustachian Tube Irradiation. Edmund P. Fowler, Jr. New York State J. Med. **49:** 187–190, Jan. 15, 1949.

Nasopharyngeal application of very lightly filtered radium has proved to be a valuable form of treatment when it is really indicated. It will not replace surgical

adenoidectomy, and midline adenoid tissue will mechanically prevent the placement of the applicator at the eustachian orifice. The only indication for the procedure is the presence of lymphoid tissue around and in the eustachian orifice which, by partially or completely blocking the canal, is causing otitis media.

An interesting table is given showing the approximate depth doses at 1, 2, and 3 cm. and 1 and 2 mm. in gamma roentgens, and an anatomical drawing of the nasopharynx in cross section is reproduced, showing the structures present at the depths given in the table.

The author adds a few words of caution in regard to handling and storing of the radium for the benefit of the otolaryngologists to whom the paper was read.

The article is recommended in the original for the drawing and depth dose table.

ZAC F. ENDRESS, M.D.
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Beta Radiation Therapy. A. D. Ruedemann. Arch. Ophth. **41:** 1–4, January 1949.

Beta radiation, administered by means of a beta-ray applicator, has been found useful in the treatment of certain ophthalmologic conditions. The applicator is so constructed that the radon is separated from the tissue to be treated by only a thin glass window. Alpha rays are absorbed by the glass, and the transmitted radiation consists of about 97 per cent beta rays and 3 per cent gamma rays. The dosage usually employed for contact therapy is 5,000 millicurie seconds, which corresponds to about 600 r and produces pronounced erythema of the skin within three days.

The author discusses briefly the treatment of overgrowths of the eyelid, and conjunctival and corneal lesions, and calls attention to the hazards involved in radiation therapy.

Two illustrations.

RADIOISOTOPES

Radioiodine in the Study and Treatment of Thyroid Disease: A Review. Mavis P. Kelsey, Samuel F. Haines, and F. Raymond Keating, Jr. J. Clin. Endocrinol. **9:** 171–210, February 1949.

A review is furnished of the use of radioiodine in the study and treatment of thyroid disease during the past decade. The following headings indicate the scope of the paper: radioisotopes of iodine; fate of radioiodine in the body; metabolism of iodine by the thyroid; factors influencing metabolism of radioiodine by the thyroid; radioiodine as a label for organic compounds; radioiodine studies in various thyroidal states; therapeutic uses of radioiodine. A bibliography of 153 references is appended.

Thirteen illustrations; 2 tables.

The Biologic Decay Periods of Sodium in Normal Man, in Patients with Congestive Heart Failure, and in Patients with the Nephrotic Syndrome as Determined by Na^{22} as the Tracer. Sam Threefoot, George Burch, and Paul Reaser. J. Lab. & Clin. Med. **34:** 1–13, January 1949.

Since a substance introduced into an organism tends to be eliminated exponentially and, mathematically, is never completely eliminated, it has been found useful, when dealing with radioactive materials, to measure the interval of time required to eliminate one-half the material. This is designated the "biologic half-life period." This figure is of importance as indicating the total rate of turnover of a given substance present in its regular form in the organism; in determination of safety factors and in dealing with safety measures from the public-health angle; in determining the suitability of a substance for a given experiment; in calculating the dosage of radioactive elements to insure levels of counts which permit accuracy of measurements. The "biologic half-life period" is useful further in that it throws light upon the nature of disease, since it is influenced by the disease process, and in the clarification of problems related to therapy, characteristics of species in animals and plants, toxicology, and other problems related to individual experiments.

The application of radioactive sodium to the study of the pathological conditions of congestive heart failure and the nephrotic syndrome is quite complicated, but the results are straightforward and simple and bring out the fact that biological half-life was not measured directly, but instead the time necessary to reduce the serum concentration to one-half the initial level and the time required to eliminate one-half the injected sodium in the urine were determined. Concentration half-life was increased about threefold in patients with congestive heart failure and about fivefold in the presence of the nephrotic syndrome. Urine half-life was increased to an even greater extent by these diseases.

Five illustrations; 2 tables. S. F. THOMAS, M.D.
Palo Alto, Calif.

Theoretic Considerations of Biologic Decay Rates of Isotopes. George E. Burch, Sam A. Threefoot, and James A. Cronvich. J. Lab. & Clin. Med. **34:** 14–30, January 1949.

This article represents the theoretical and mathematical background for the paper abstracted above. Equations are derived which make it possible to predict the influence of variations of intake and output of a nontracer substance and of the size of its compartment (*i.e.*, the portion of the organism under study) upon the concentration within the organism and elimination from the organism of a tracer substance administered in a single dose.

The results of this study bring out clearly the need and reason for exercising caution in interpretation of data concerned with measuring variations in concentration and total content of the tracer substance.

The authors point out that, although the discussion is chiefly concerned with problems of sodium tracer studies, these theoretic considerations apply to any type of tracer experiment, regardless of the size or location of the compartment and regardless of whether the tracer is stable or radioactive.

[The authors have done a remarkable piece of work in simplifying some of the mathematical considerations of tracer studies, which not only confuse but often make results unintelligible to the practising physician.—S.F.T.]

Eight illustrations. S. F. THOMAS, M.D.
Palo Alto, Calif.

EFFECTS OF RADIATION; EXPERIMENTAL STUDIES

A Critical Analysis of the Syndrome of Acute Total Body Radiation Illness, Its Role in Atomic Warfare and Its Influence on the Future Practice of Military Medicine. Eugene P. Cronkite and William H. Chapman. Naval Medical Research Institute, Project NM 007 039, Report No. 19, Jan. 3, 1949. Also in Mil. Surgeon **104:** 7–21, January 1949.

The pattern of injuries due to bombs of the atomic fission variety shows three concentric overlapping zones in relation to distance from the explosion. The authors' description of the acute radiation illness in these three zones is based on the meager reports from Hiroshima and Nagasaki, supplemented by animal experiments at Bikini.

In the innermost zone, Zone I, the ionizing radiation is highly in excess of the absolute lethal dose. At its outer limit an average figure of 1,500 r is assumed. After exposure to these massive doses, nausea, vomiting and malaise will appear within a few hours. These symptoms may subside or merge with fever and diarrhea appearing as early as the day after exposure. Leukocytes practically disappear within twenty-four hours, scattered petechiae occur, diarrhea becomes more severe, and the condition of the injured may deteriorate rapidly. In this severest group death occurred suddenly between the fourth and tenth day among the Japanese. This rapid tempo, with a short latent period (i.e., between the initial symptoms and recrudescence of the illness, or none at all, is borne out by experiments on mice, which may die while undergoing 1,000-kv. roentgen irradiation in excess of 32,000 r during a period of four and a half hours.

In Zone II, starting at about 800 meters and extending to about 2,000 meters from the center of the bomb explosion, the dose may be considered as between 1,500 and 150 r. The tempo of the illness is more rapid in the upper dosage range. Nausea, vomiting, diarrhea, and malaise come on in a few hours after exposure, then subside and are followed by a variable latent period during which symptoms are almost entirely absent. During this latent period leukopenia, thrombopenia, and disappearance of reticulocytes become progressively evident. The latent period is roughly inversely proportional to the dose of radiation received and is terminated by recrudescence of the symptoms. The duration of the latent period in the Japanese exposed at Hiroshima and Nagasaki was between seven and twenty-eight days. In the Bikini animals this period tended to be shorter. The authors point out, however, that all signs and symptoms take place at a more rapid rate in experimental animals than in the Japanese casualties.

The syndrome which follows the latent period is predominantly gastro-intestinal in effect, winding up in an intractable bloody diarrhea. In addition, purpura, fever and pancytopenia become progressively worse. Accompanying these phenomena are secondary disturbances, such as laryngitis, stomatitis, pharyngitis, tonsillitis, gingivitis, and ulcerative lesions of the skin and genitalia. Interestingly enough, while epilation was common, complete loss of hair was the exception. Recovery did not commonly ensue if the total leukocyte count fell below 800, nor did death occur, as a rule, if the count remained over 1,500. If reticulocytosis is established, recovery usually, but not always, follows.

From the clinical point of view, deaths resulting from a large dose of irradiation could be divided into two general groups: (1) the panleukopenic group, in which infections (particularly of the necrotizing nonpurulent type) predominated, and (2) the hemorrhagic group. There is, of course, overlapping.

The clinical course in the third zone, that of sublethal exposures, under 150 r, was similar in many respects to that observed in the intermediate dose range, but was less severe and no deaths occurred solely from the effects of radiation. The initial symptoms and signs are those described above, but the rate at which they appear and their severity are less in this dosage range.

The fact that no single factor is responsible for the production of many of the signs and symptoms of irradiation illness makes an adequate description of its pathogenesis most difficult. The order of sensitivity of the cells and tissues is outlined as follows: (1) lymphocytes, (2) erythroblasts, (3) germinal epithelium of the testis, (4) myeloblasts, (5) the epithelial lining of the base of the gastro-intestinal crypts, (6) germinal cells of the ovary, (7) basal layer of the skin, (8) connective tissue, (9) bone, (10) liver, (11) pancreas, (12) kidney, (13) nerve, (14) brain, (15) muscle.

Many phenomena observed in the course of radiation illness are similar to anaphylactoid responses. For example, the liberation of heparin and histamine, the similarity to hypersensitive states, the toxicity produced by and the general clinical course of total body ionizing radiation illness, all suggest that sensitization to an unknown factor may be occurring during the latent period.

In general, it seems unnecessary to hypothesize the presence of circulating "radiotoxins" or absorption of toxins through a bowel, the permeability of which has been altered.

Therapeutically the occasional accidental case of acute ionizing irradiation illness and the thousands of cases that would occur following an atomic bomb explosion present two different problems. Specific measures applicable to the isolated case include: (1) prophylactic use of penicillin, or perhaps streptomycin to combat the gram-negative bacilli, (2) transfusions of fresh, whole blood, in amounts equivalent at least to 100 c.c. per day; (3) fluids and electrolytes given in adequate amounts in order to produce a minimum of 1,000 c.c. of urine a day. Other drugs that have been suggested are: pyridoxine and its analogues, folic acid, liver extract, methionine, adrenal cortical hormones, antihistaminics, rutin and associated flavonone derivatives, various members of the vitamin B group, hydrochloric acid, and antiheparin agents (toluidine blue and protamine). Perhaps the most important factor, however, lies in complete physical and mental rest and perhaps mild sedation, since in experiments on mice it was observed that the mortality increased rapidly as the animals were handled and crowded in their cages.

In military medicine the objectives must be influenced by other than individual considerations. The problem here will be the rapid segregation of casualties into three groups on the basis of the amount of radiation received, and therefore the possibility of survival. For this purpose the development of an easily read casualty dosimeter is a primary need.

A continuation of basic and applied research along the lines suggested in this paper is urged. Further information on the influence of diet and environmental factors on survival after exposure to doses in the lethal range is needed. Information concerning the relationship of the adaptation syndrome and the pituitary adrenocortical mechanism to radiation illness is desirable. Autosensitization and anaphylactoid phenomena in radiation illness must be clarified still further.

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Observations on the Blood of Cyclotron Workers. M. Ingram and S. W. Barnes. Physical Rev. **75:** 1765, June 1, 1949.

In a Letter to the Editor attention is called to bilobed large mononuclear cells, thought to be early lymphocytes, which have been observed in the blood of personnel of the 130-in. Rochester cyclotron. They occur in small numbers, a few per thousand leukocytes.

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Response of Germ Cells to Gonadotropic Hormones in X-Ray Injured Ovaries of Young White Mice. J. M. Essenberg. West. J. Surg. **57:** 61–66, February 1949.

The ovaries of 34 mice three to four weeks old were exposed to doses of 244 to 300 r and the group was then divided into two parts. One constituted a control group; animals of the other group were treated with gonadotropic hormone either by injection of gonadophysin twice weekly for three months or by implantation subcutaneously of pituitary gland tissue. At the end of two to three months the remaining mice (some were sacrificed in the meantime) were mated to normal males and after another two to three months all were sacrificed.

Degeneration of the germinal epithelium took place rapidly after irradiation and at the end of three months most of the control ovaries were devoid of reproductive elements. The animals treated with gonadotropic hormone showed remarkable regeneration even to the point of producing ova and follicles. None of the follicles developed completely, however; degeneration took place before they were quite mature. No young resulted from any of the matings in the treated or control groups.

The effects were not entirely uniform—some treated ovaries failed to regenerate while a few control cases showed some spontaneous recovery.

Eight photomicrographs. ZAC F. ENDRESS, M.D.
Pontiac, Mich.

The Lymphocyte. Studies on Its Relationship to Immunologic Processes in the Cat. Charles G. Craddock, Jr., William N. Valentine, and John S. Lawrence. J. Lab. & Clin. Med. **34:** 158–177, February 1949.

A review of the existing knowledge of the relationship of lymphoid tissue and the lymphocyte to immunologic processes is presented. Brief analysis is made of the theory of pituitary-adrenal cortical control of lymphoid tissue structure and function.

A study of lymphocytes collected from the thoracic duct lymph of cats, with the use of typhoid vaccine as an antigen, revealed no antibody within extracts of washed lymphocytes.

A group of cats was exposed to 1,500 r whole body roentgen radiation during the period of thoracic duct drainage. This amount of radiation is in excess of the dosage required for maximal lymphoid tissue destruction. Lymphocyte production diminished markedly after this procedure, as evidenced by the fall in output of thoracic duct lymphocytes. Exposure of the animals to radiation did not significantly alter the antibody content of the cell-free lymph fluid. This is interpreted as indicative of the slight or negligible amount of antibody released from lymphoid tissue by x-ray damage of cells.

It was observed that the antibody concentration in the blood serum rose significantly during the period of thoracic duct drainage (six to eight hours) in 50 per cent of the animals. This was true in the animals exposed to x-rays as well as the others. This continued rise in serum antibody titer in spite of lymph drainage, particularly in those animals exposed to x-rays two hours after operation, suggests either continued antibody formation by some more radioresistant tissue than lymphoid or release of preformed antibody from cells or tissue spaces directly into the blood without the necessity of lymphocytic transport of antibody.

Administration of large doses of adrenal cortical hormones to a small group of cats failed to cause any significant alteration in the antibody content of cell-free lymph fluid.

The authors conclude that, under the conditions of the experiments, no evidence for lymphocytic transport of antibody to the blood was found.

One graph; 3 tables.

Distribution Studies in Mice Following the Intravenous Injection of Diethyl β-iodoethyl Amine Hydrochloride Prepared with Radioactive Iodine. Arnold M. Seligman, Alexander M. Rutenburg, and Orrie M. Friedman. J. Nat. Cancer Inst. **9:** 261–270, February 1949.

Using a simple nitrogen mustard, diethyl β-iodoethyl amine hydrochloride, prepared with radioactive iodine, the authors attempted to discover whether the mustard reaches neoplastic tissue as such, or whether a reaction product of the mustard with some constituent of the blood is responsible for the cytotoxic effect. Distribution studies of the radioactive mustard in the tissues of normal and tumor-bearing mice were done. The results indicated that most of the mustard was rapidly broken down, but that a small portion reached the tissues intact and penetrated the cells. The highest concentration of radioactivity was noted in blood, lung, and lymph nodes, conforming to the locus of clinical activity of the mustards.

Five graphs; 7 tables.

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